Virginia Coastal Plain Model
2005 Withdrawals Simulations

05 December 2006
Office of Ground Water Withdrawal Permitting
Water Resources Division

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1. 2005 Reported Use Simulation

A Virginia Coastal Plain Model ("VCPM") simulation was performed representing the groundwater withdrawals reported to DEQ for calendar year 2005. Reports were obtained in electronic format from the Virginia Water Use Data System ("VWUDS"), and the DEQ Piedmont Region ("PRO") and Tidewater Region ("TRO") permit compliance reports. The Virginia Water Use Data System houses water use reported under the Water Withdrawal Reporting Regulation. This regulation requires annual reporting of monthly surface and groundwater withdrawals exceeding an average of 10,000 gallons per day. DEQ Regional offices receive water use data from Ground Water Withdrawal Permit holders as a condition of their permits.

Withdrawals reported within the Coastal Plain were assigned to aquifers and grid cells using a model allocation table developed by the USGS and transferred to DEQ Ground Water Permitting Program in 1997. Records for regulated wells are added or updated as new information becomes available during the permitting process. Staff geologists review site and existing hydrogeologic framework data to determine the source aquifer(s) for each permitted well. Row and column assignments are made using well locations (latitude and longitude) to plot the position on a GIS coverage of the VCPM finite-difference grid. Additions have been made to the model allocation table for wells outside the Ground Water Management Areas ("GWMAs"). The list of wells not in the coastal plain sediments or in the active model area ("Outside Wells") has also expanded. These reference sets were updated using data from the legacy STORET and VWUDS files.

The reported withdrawals were simulated at a constant rate (cfs) equivalent to the annual average and to steady-state conditions. Lateral flow boundaries (north and south) continue to be simulated through a series of wells assigning withdrawal or injection to boundary cells. These boundary stresses have not been edited by DEQ and are presumed to be the 1980 stresses developed using the larger RASA model.

A total use of 100.40 Mgd in the Virginia Coastal Plain was reported to the regional offices as permit compliance reports and to VWUDS. The use reported to VWUDS includes that portion of agricultural use reported for which there was adequate information to make a model assignment. Of the 100.40 Mgd reported, 97.99 Mgd was successfully allocated for this simulation. Of the 2.41 Mgd that could not be allocated, 0.98 Mgd was reported for undocumented wells and 1.43 Mgd was reported for wells determined to be outside the modeled area or wells not in coastal plain sediments. A breakdown of the reported water use data by county appears in the following table:

Table 1-1. 2005 Water Use Report - Withdrawals modeled by city/county

County/City (* = non-GWMA)	Use Allocated To Model (MGD)	Use Not Allocated To Model (MGD)	
		outside model boundaries or not Coastal Plain	unresolved
Accomack	3.73	0.14	0.02
City of Alexandria		0.02	
*Arlington		0.02	
*Caroline	*0.38	0.19	0.12
Charles City	0.06		
City of Chesapeake	4.32		
Chesterfield	0.24		0.16
*Essex	*0.38		
*Fairfax	*0.03	0.28	0.11
City of Franklin	1.16		
*Gloucester	*0.66		
City of Hampton	0.08		
Hanover	0.63		
Henrico	0.05		
Isle Of Wight	35.76		0.04
James City	4.99		0.06
*King & Queen	0.01		
*King George	*0.72	0.02	0.22
King William	19.13		0.01
*Lancaster	*0.04		
*Loudoun		0.09	
*City of Manassas		0.02	
*City of Manassas Park		0.41	
*Mathews			
*Middlesex	*0.08		0.10
New Kent	0.76		
City of Newport News	2.41		
City of Norfolk	0.20		
Northampton	0.92	<0.01	0.01
*Northumberland	*0.16		0.02
*City of Petersburg			
City of Portsmouth	2.07		
Prince George	0.40		
*Prince William	*0.02	0.20	
*City of Richmond		0.02	0.02
*Richmond County	*0.31		
Southampton	6.37		0.01
*Spotsylvania		0.01	<0.01
*Stafford			0.01
City of Suffolk	8.48		
Surry	0.50		
Sussex	0.93	0.01	0.02
City of Virginia Beach	0.22		
*Westmoreland	*0.89	<0.01	0.04
City of Williamsburg	0.69		0.02
York	0.21		
TOTAL	97.9912	1.4311	0.9815

The reported amounts that were simulated (including irrigation) have been totaled by aquifer and are presented in the following table:

Table 1-2. Reported Use - Total Simulated by Aquifer

Aquifer	Total Use (MGD)
Columbia	0.43
Yorktown-Eastover	5.35
Chickahominy-Piney Point	4.22
Aquia	0.14
Virginia Beach	0.08
Upper Potomac	16.01
Middle Potomac	56.93
Lower Potomac	14.83
TOTAL	97.99

The model outputs (hydraulic heads) are assigned to corresponding GIS grid cells by a Fortran program and then converted to an ArcView shapefile. The head values are then contoured using ESRI's Spatial Analyst. Smoothest contours were generated using the spline method (20 neighbors). Contour intervals were selected consistent with the graphics produced for previous annual simulations (see Attachment A).

Field observations of water levels for the same period in the coastal plain well monitoring network were supplied by the USGS and used to produce GIS point coverages of average water levels for each of the six confined aquifers monitored jointly by the USGS and DEQ. These maps are included as Attachment B.

Comparison of the two sets of maps with similar maps produced for the water use simulations from previous years shows that the simulated heads continue to be higher than observed for most model cells where field data exists. In some cases this difference may be exacerbated by the position of an observation well relative to a cone of depression and the model calculation of an averaged head over an entire model cell. Generally the difference between observed and simulated water levels is a documented and increasingly divergent trend. The largest differences occur in the Upper Potomac Aquifer in Southampton County near the North Carolina line and in the Middle Potomac Aquifer in King George County near the Maryland line.

2. 2005 Total Permitted Simulation

2.1 Withdrawals simulated

9VAC25-610-110.D.3.h ("Criteria for issuance of permits.") of the GWMA Regulations requires the evaluation of proposed withdrawals in combination with all existing lawful withdrawals. This simulation is created by replacing the reported use amounts (in the 2005 Reported Use simulation) for all GWMA permit holders with the maximum annual withdrawal limit allowed under the terms of active permits. This individual permit amount was evenly divided between the active and proposed wells of the permit. For permits with special conditions requiring limits on groups of wells, the maximum amount per well grouping was divided evenly between all wells in the group. For all wells screened in multiple aquifers, the withdrawal was then further divided among multiple aquifers by the use of the existing model allocation table. Pending permits (those awaiting VDH approval) were also modeled at their maximum annual limit. For existing systems, in-use wells that are to be taken out of service under the pending permit were modeled at their reported use amount with the pending permit limits applied to all wells listed on the new permit. All of the permitted withdrawals simulated in the "2005 Total Permitted Simulation" are listed in Attachment C. Withdrawals from wells that have reported use but that were not included in a permitted withdrawal were also included as background withdrawals in the "Total Permitted Simulation." This method resulted in a total simulated regional withdrawal of 158.17 Mgd, which is 60.18 Mgd greater than the total amount reported as actual use.

Table 2-1. Total Permitted – Withdrawals simulated

Maximum Permitted Amounts	145.99 MGD
Other Reported Withdrawals	12.18 MGD
Total Simulated Withdrawals	158.17 MGD

Contour maps of the Total Permitted simulation appear as Attachment D in this document. These maps depict the water level elevations for each confined aquifer predicted to occur if all permitted users were to withdrawal at their maximum lawful limit.* These maps were contoured consistent with the process for the 2004 Reported Use Simulation and other previous water use reports.

*Except for the City of Norfolk (GW0037500) whose withdrawals are simulated at the "average of their actual historical ground water usage" due to a special provision in § 62.1-263 of the Ground Water Management Act (GWMA) of 1992.

2.2 Critical Surface

The Ground Water Withdrawal Regulations require a technical evaluation of the withdrawal requested in a ground water withdrawal permit application. Permits can only be issued if this assessment "demonstrates that the proposed withdrawal in combination with all existing lawful withdrawals will not lower water levels, in any confined aquifer that the withdrawal impacts, below a point that represents 80% of the distance between the historical prepumping water levels in the aquifer and the top of the aquifer." A "critical surface" elevation value is calculated for each active model cell in an aquifer using the historical prepumping water levels from the Virginia Coastal Plain Model and the aquifer top elevations from the model framework. Critical surface elevations are *not* calculated for a particular aquifer in model cells identified as constant head in that aquifer, model cells under unconfined conditions in that aquifer, or model cells that have starting heads below the aquifer top. Therefore, any cell meeting one of these conditions will not be considered in evaluating the "80% drawdown criterion."

2.2.1 VCPM Cells Violating the 80% Drawdown Criterion

The 2005 Total Permitted simulation shows areas in the interior portions of the Coastal Plain for the Middle and Upper Potomac aquifers, the Aquia, Chickahominy-Piney Point and Yorktown-Eastover aquifers where the predicted water levels (at steady-state conditions) are below the critical surface for those aquifers. In more than half of the cells with water levels predicted to be below the critical surface, the predicted water levels are also below the aquifer top represented in the model framework. This analysis is based on aquifer parameters as they are estimated in the current Virginia Coastal Plain Model. This model was developed in the late eighties and was revised around 1994 as the model framework was migrated to GIS.

Maps of all areas violating the 80% drawdown criterion are presented in Attachment E. Areas with water levels also predicted to be below aquifer tops are noted on these maps.

2.2.2 VCPM Cells Violating the 80% Drawdown Criterion (all permittees at their actual permitted amount)

The Ground Water Withdrawal regulations require all proposed withdrawals to be evaluated "in combination with all existing lawful withdrawals". However, the City of Norfolk (GW0037500) withdrawals are simulated at the "average of their actual historical ground water usage" due to a special provision in § 62.1-263 of the Ground Water Management Act (GWMA) of 1992. Therefore, the total withdrawal given in Table 2-1 includes withdrawals from the Norfolk wells that equal the average of their historic reported use. A second "Total Permitted Simulation" was performed to include Norfolk at their permitted limit. The total withdrawal is 13.5 Mgd greater when Norfolk is simulated at their permitted limit. The total simulated withdrawals for this scenario are given in Table 2-2.

Table 2-2. Total Permitted – Withdrawals simulated (comparison of the two total permitted scenarios)

	(with Norfolk wells simulated at average historic use)	(with Norfolk wells simulated at yearly permit limit)
Maximum Permitted Amounts	145.99 MGD	159.49 MGD
Other Reported Withdrawals	12.18 MGD	12.18 MGD
Total Simulated Withdrawals	158.17 MGD	171.97 MGD

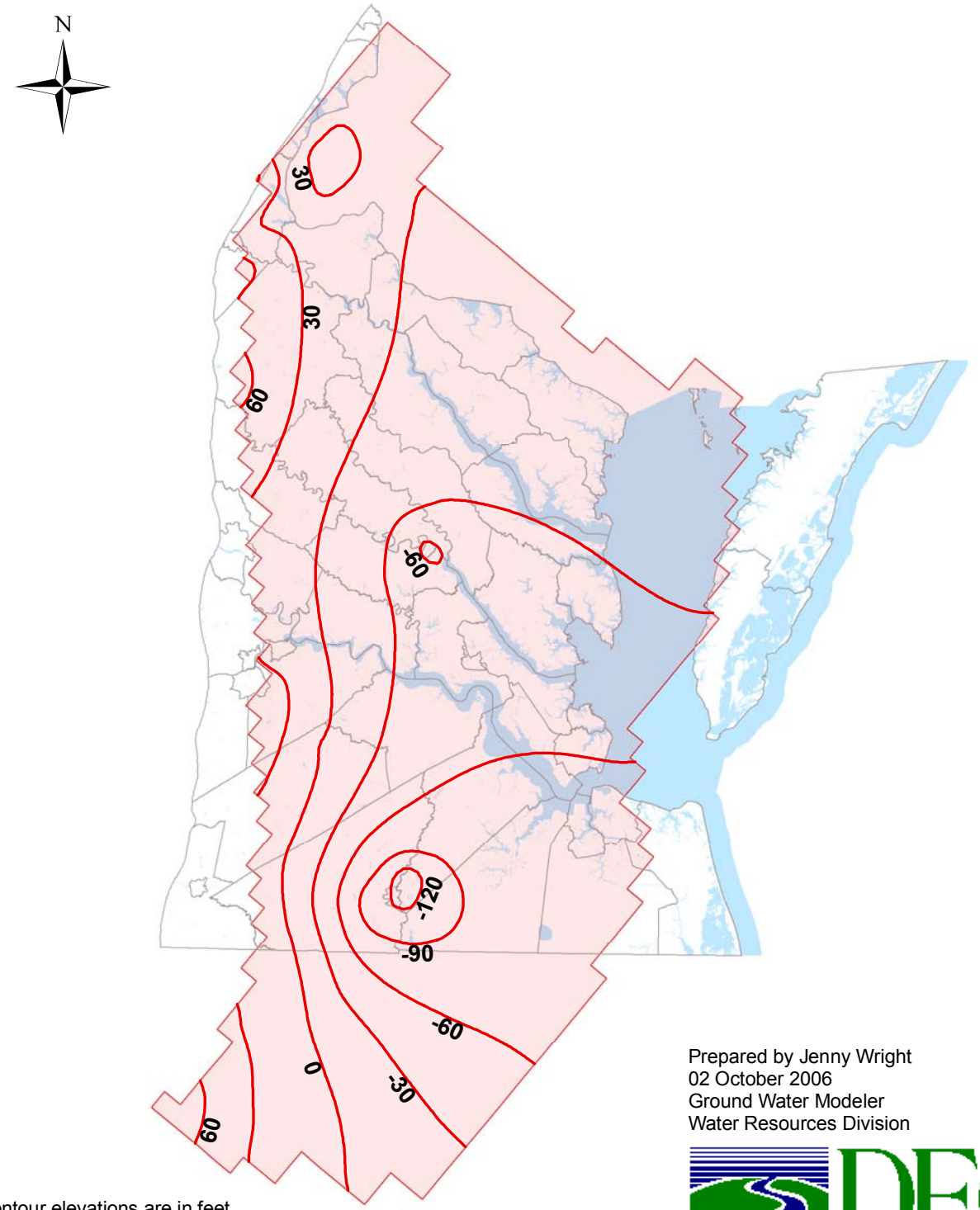
The three maps included in Attachment F examine the change in predicted water levels below the critical surface between a total permitted simulation as prescribed by the GWMA of 1992 and a total permitted scenario including the City of Norfolk at their actual permitted amount instead of at the average of their historical ground water usage.

The number of cells with water levels predicted to be below the critical surface increases in the Middle Potomac, Upper Potomac and Aquia aquifers when the City of Norfolk is simulated at their actual permitted amount. The additional cells violating the 80% drawdown criterion occur primarily in the counties of Southampton, Sussex and, to a lesser degree, Prince George.

Attachment A

Simulated Potentiometric Contours
2005 Reported Use

Simulated Potentiometric Contours
Lower Potomac Aquifer
2005 Reported Use



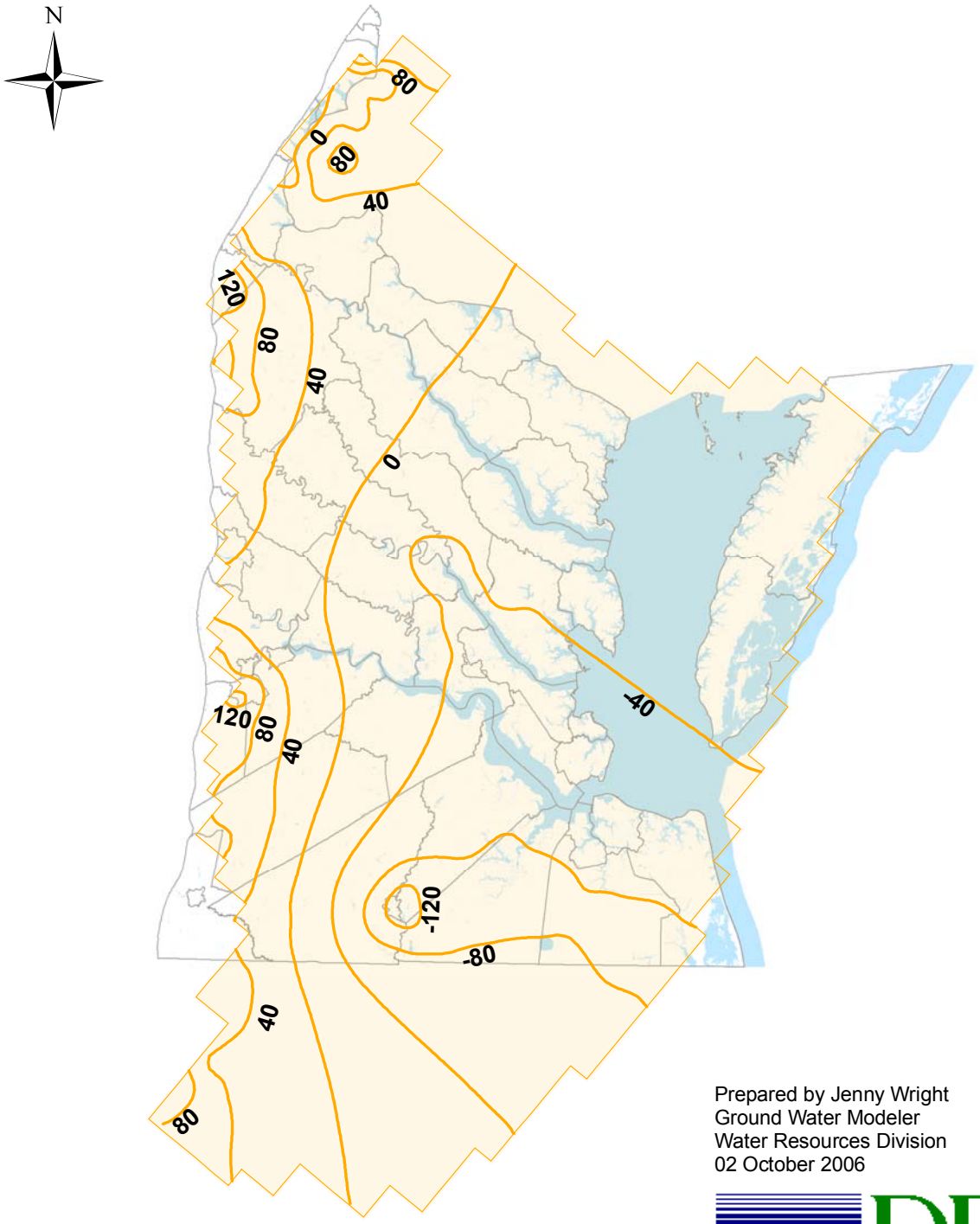
Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

0 20 40 80 Miles

Prepared by Jenny Wright
02 October 2006
Ground Water Modeler
Water Resources Division

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
Middle Potomac Aquifer
2005 Reported Use



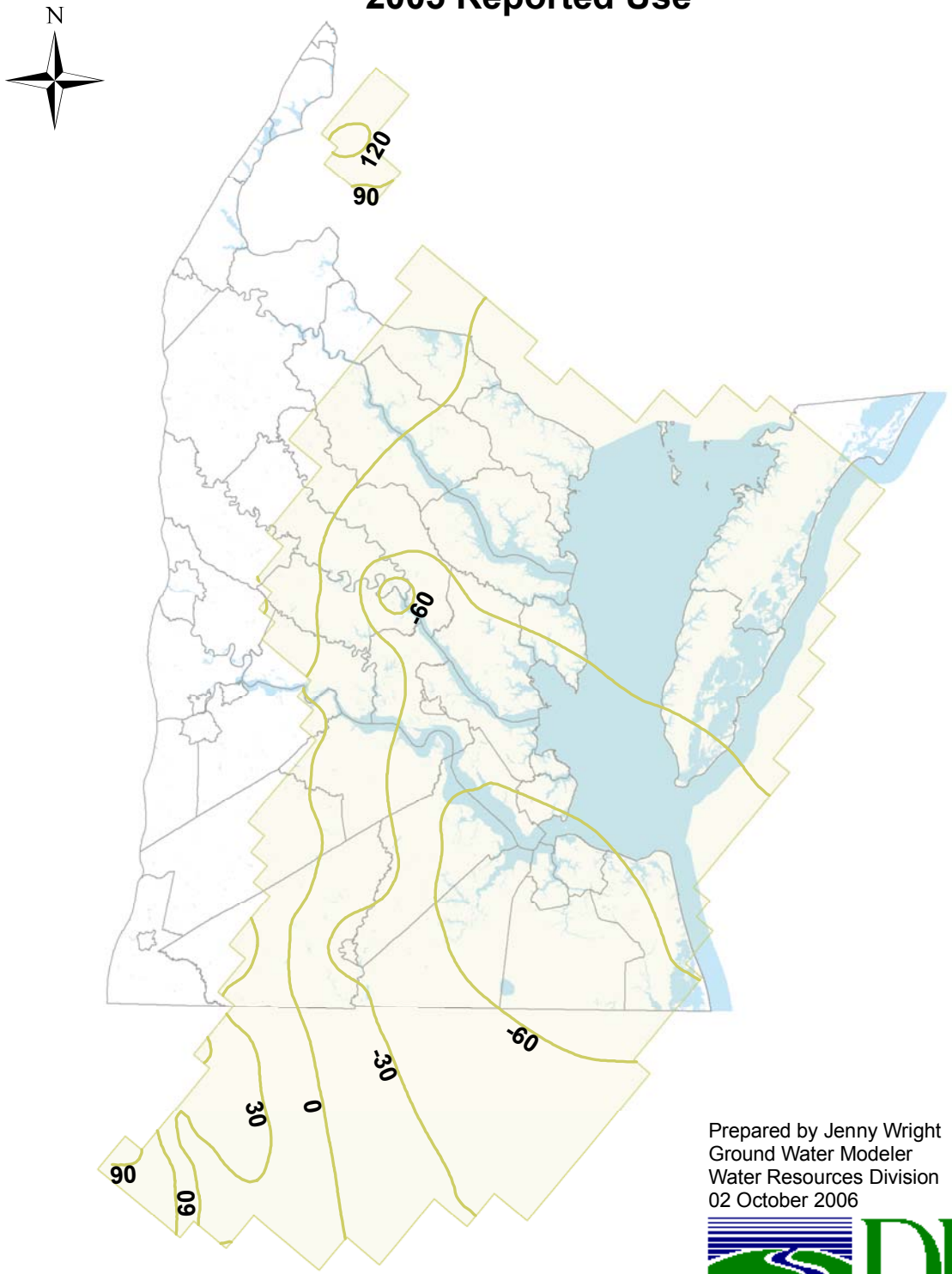
Contour elevations are in feet relative to mean sea level (msl) and at 40 ft intervals.

0 10 20 40 60 80 Miles

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
02 October 2006

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
Upper Potomac Aquifer
2005 Reported Use



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
02 October 2006

DEQ
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Simulated Potentiometric Contours
Virginia Beach Aquifer
2005 Reported Use

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
02 October 2006

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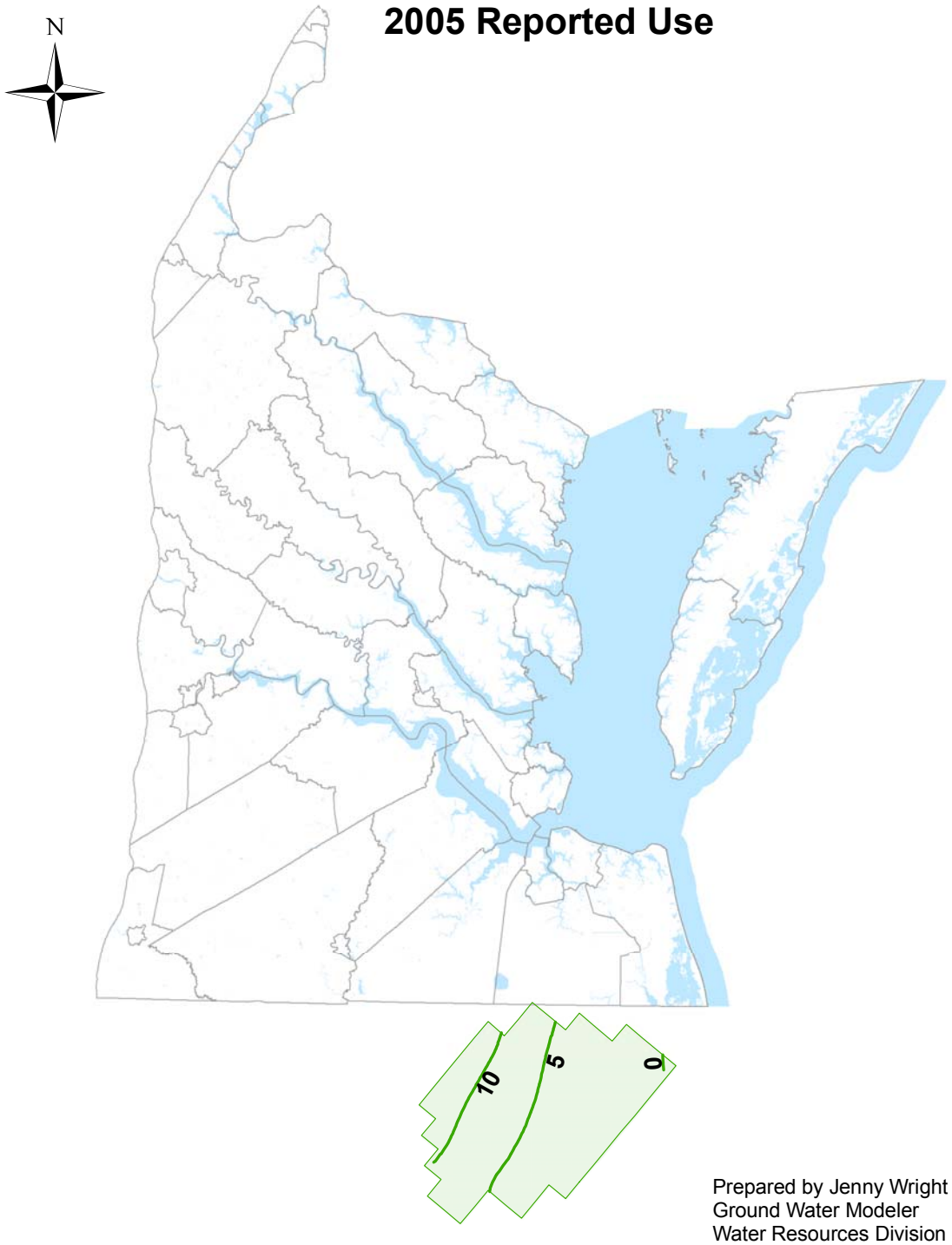
Contour elevations are in feet relative to
mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Simulated Potentiometric Contours
Pee Dee Aquifer
2005 Reported Use



Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
02 October 2006

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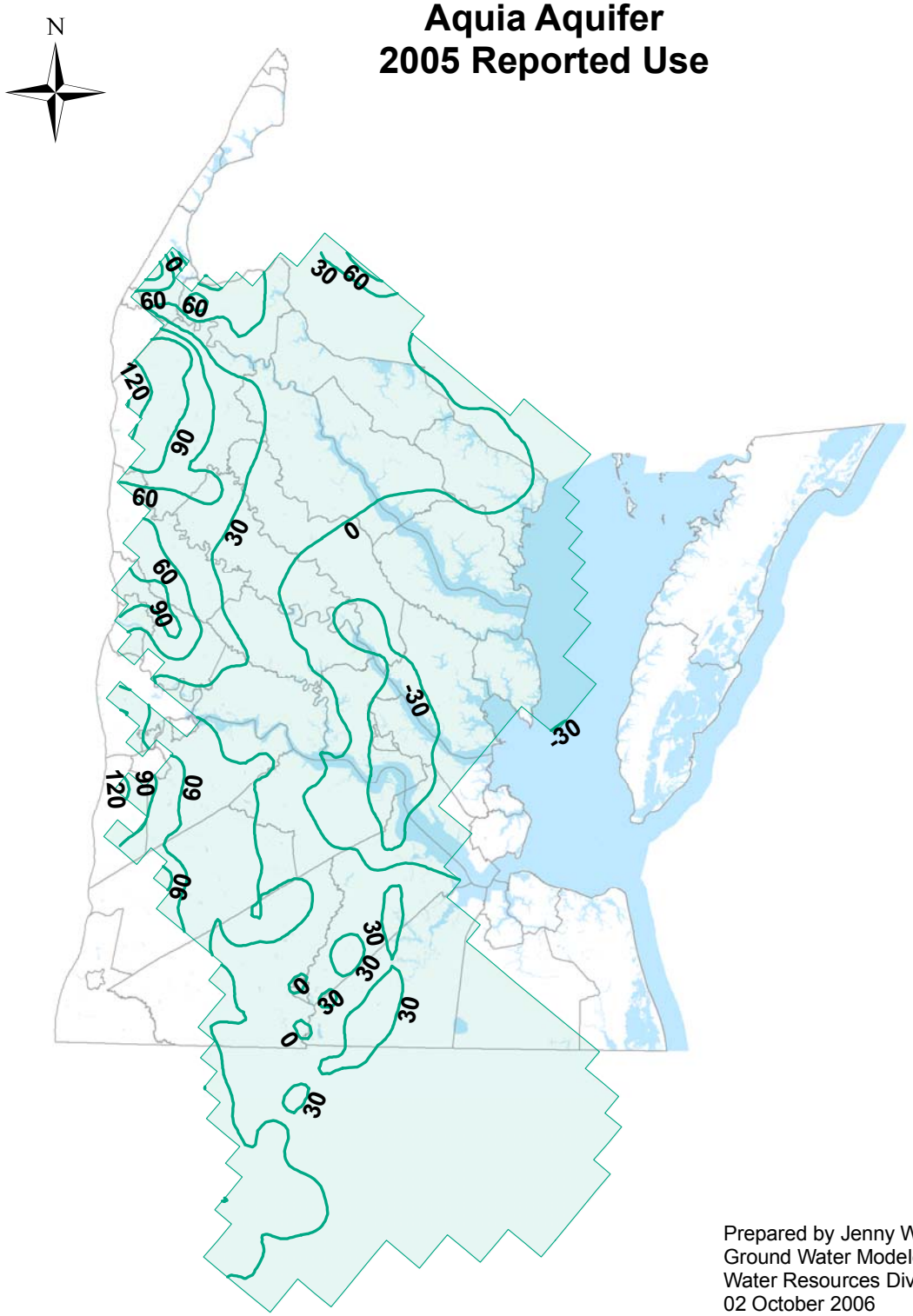
Contour elevations are in feet relative to
mean sea level (msl) and at 5 ft intervals.

0 10 20 40 60 80 Miles

Simulated Potentiometric Contours
Aquia Aquifer
2005 Reported Use



Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
02 October 2006

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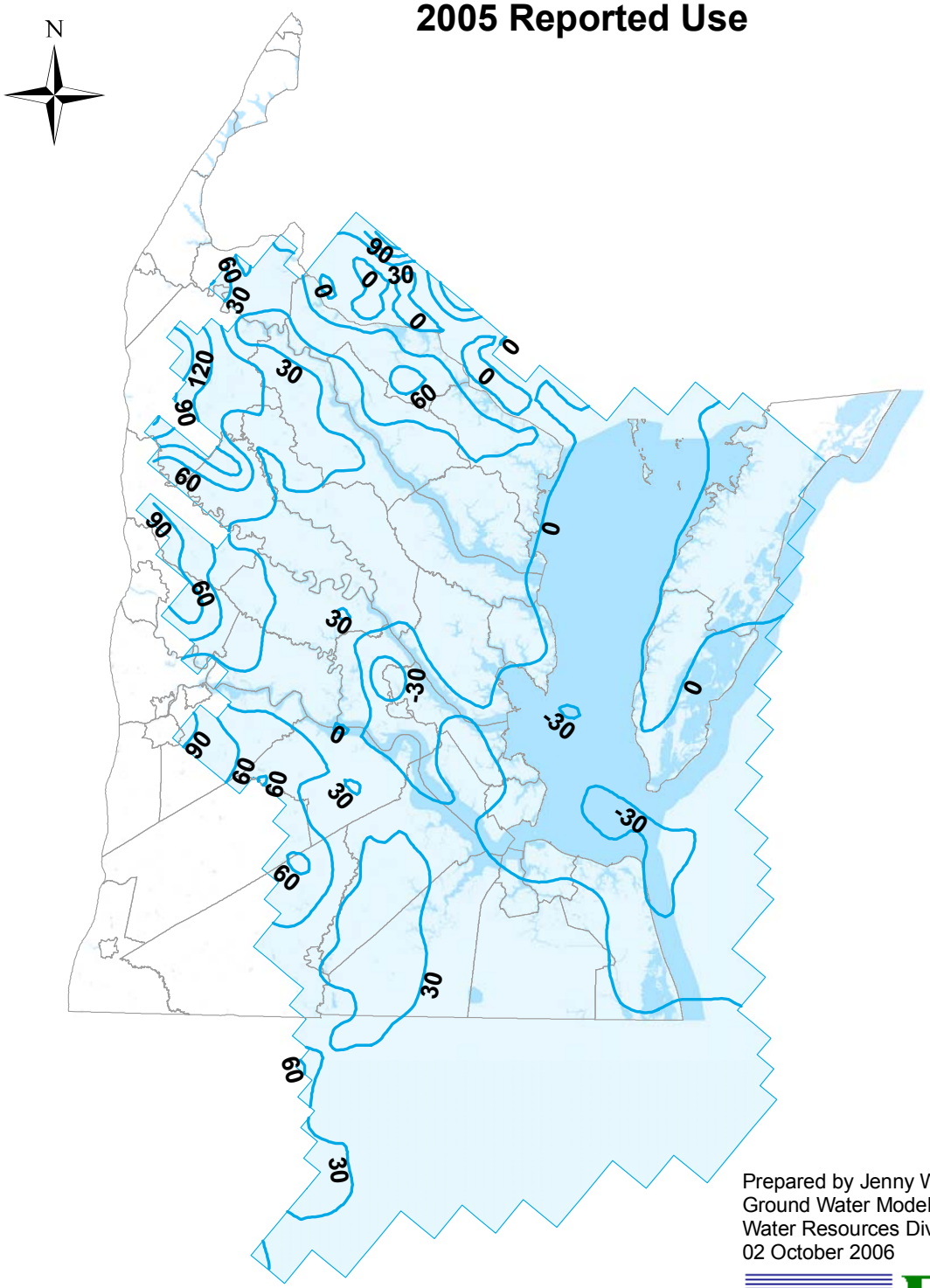
Simulated Potentiometric Contours
Chickahominy-Piney Point Aquifer
2005 Reported Use



Prepared by Jenny Wright
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Water Resources Division
02 October 2006

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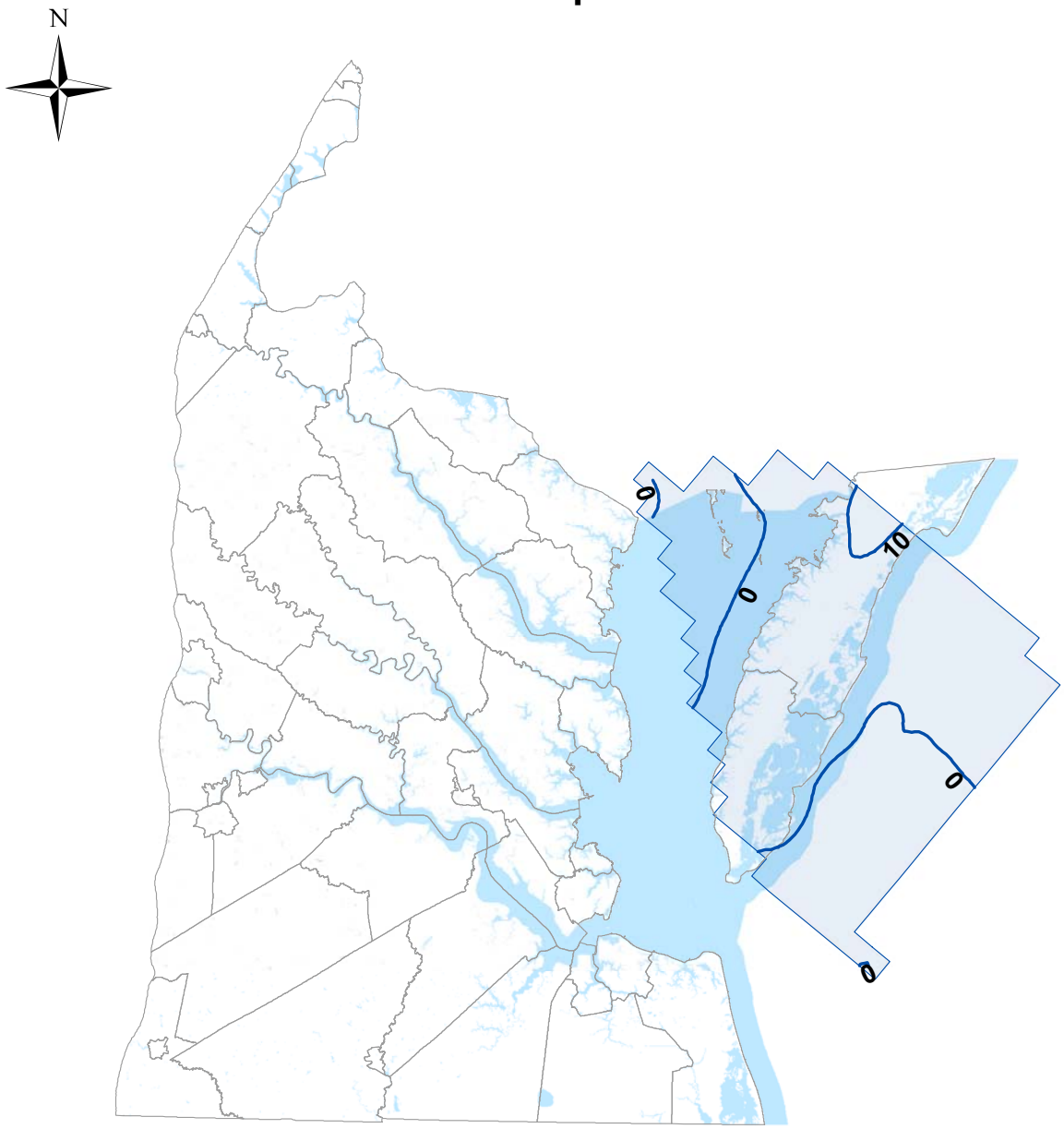
Contour elevations are in feet relative to
mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Simulated Potentiometric Contours
St. Mary's Choptank Aquifer
2005 Reported Use



Prepared by Jenny Wright
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02 October 2006

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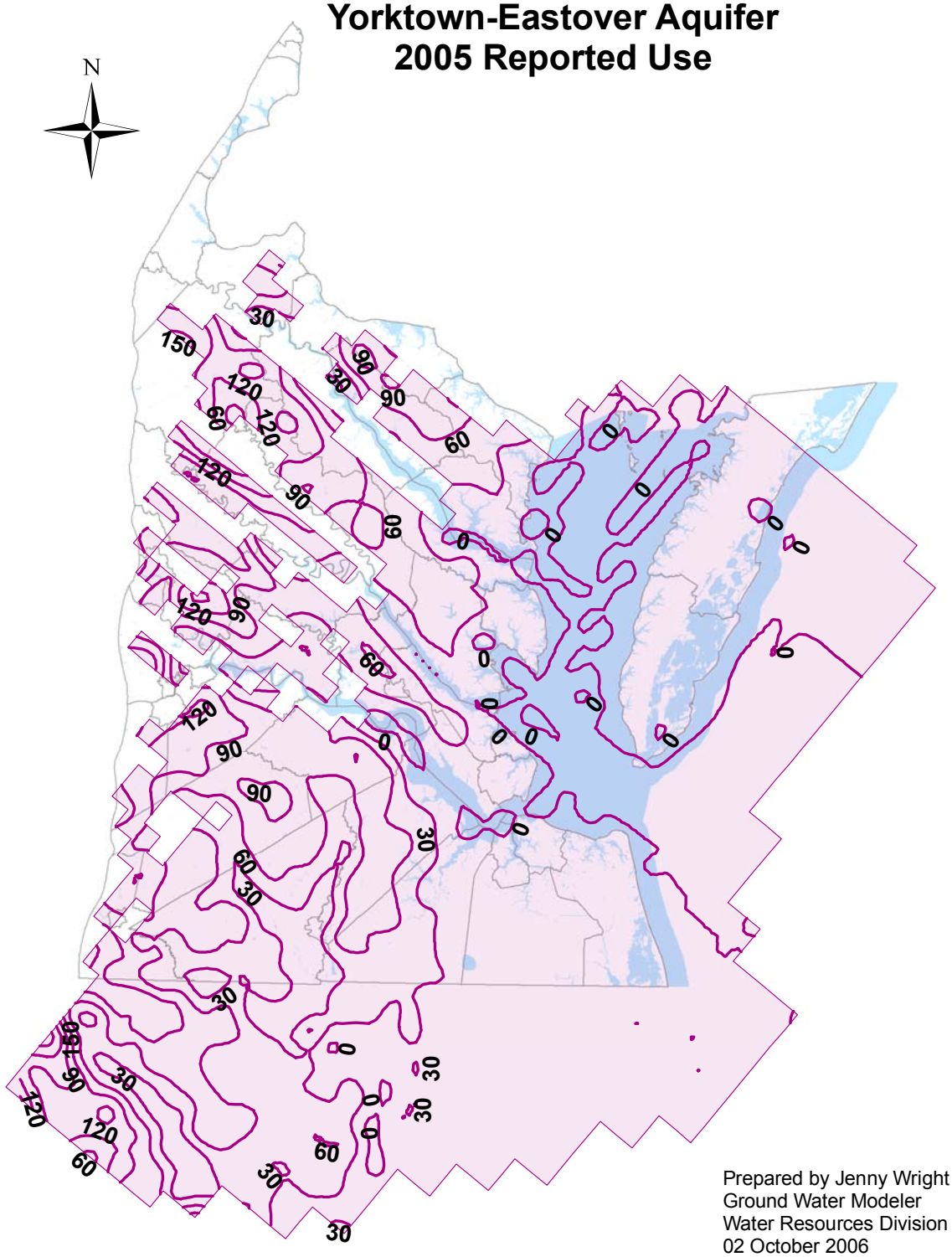
Contour elevations are in feet relative to
mean sea level (msl) and at 10 ft intervals.

0 10 20 40 60 80
Miles

Simulated Potentiometric Contours
Yorktown-Eastover Aquifer
2005 Reported Use



Contour elevations are in feet relative
to mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80
Miles

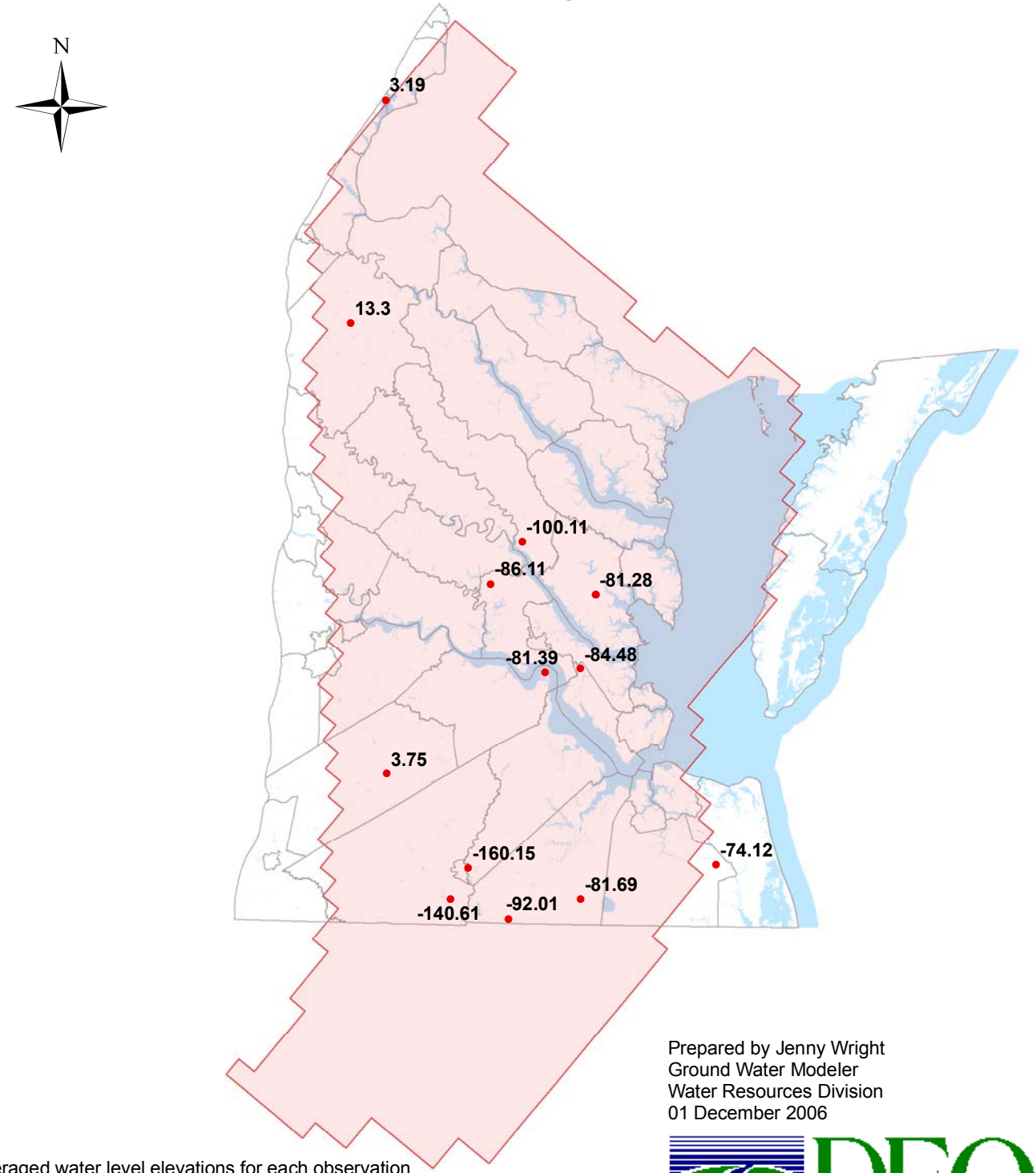
Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
02 October 2006

VIRGINIA DEPARTMENT OF
ENVIRONMENTAL QUALITY

Attachment B

Observed Water Levels
Annual Average 2005

Observed Water Levels
Lower Potomac Aquifer
Annual Average 2005



Averaged water level elevations for each observation well are in feet relative to mean sea level (msl).

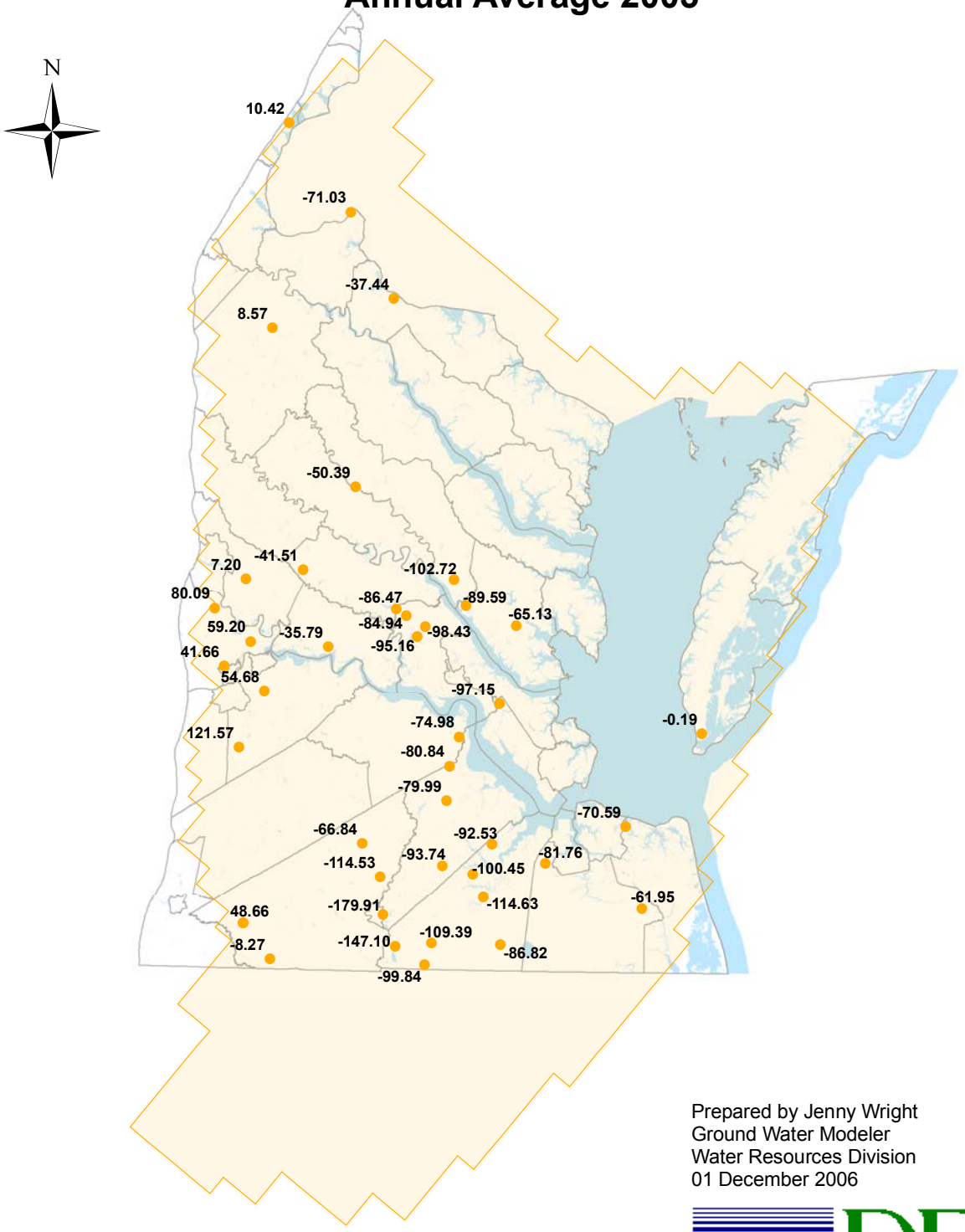
0 20 40 80 Miles

Active Model Area for Lower Potomac Aquifer

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
01 December 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Observed Water Levels
Middle Potomac Aquifer
Annual Average 2005



Averaged water level elevations for each observation are in feet relative to mean sea level (ft).

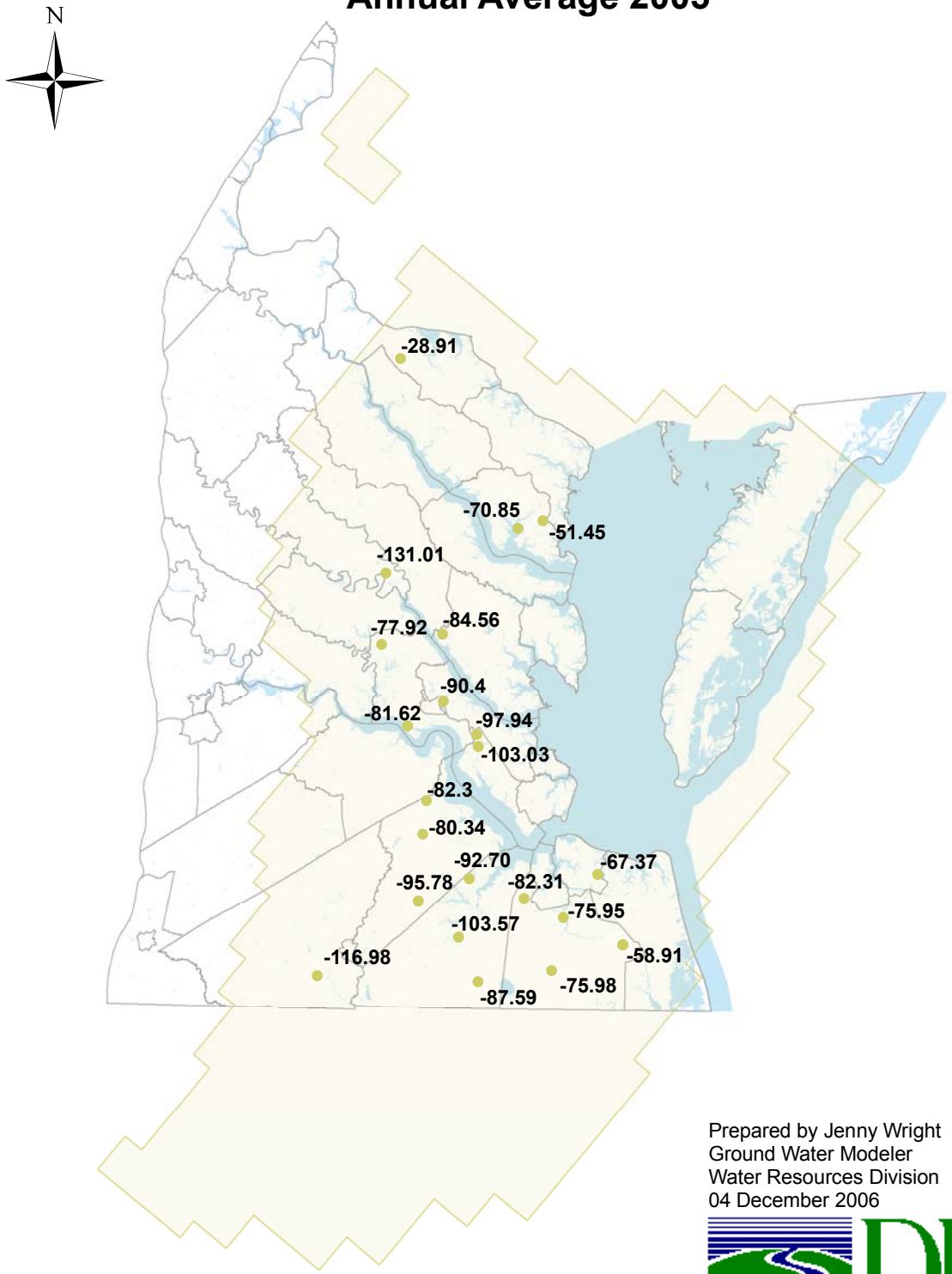
0 10 20 40 60 80 Miles

Active Model Area for Middle Potomac Aquifer

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
01 December 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Observed Water Levels
Upper Potomac Aquifer
Annual Average 2005



Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
04 December 2006

DEQ
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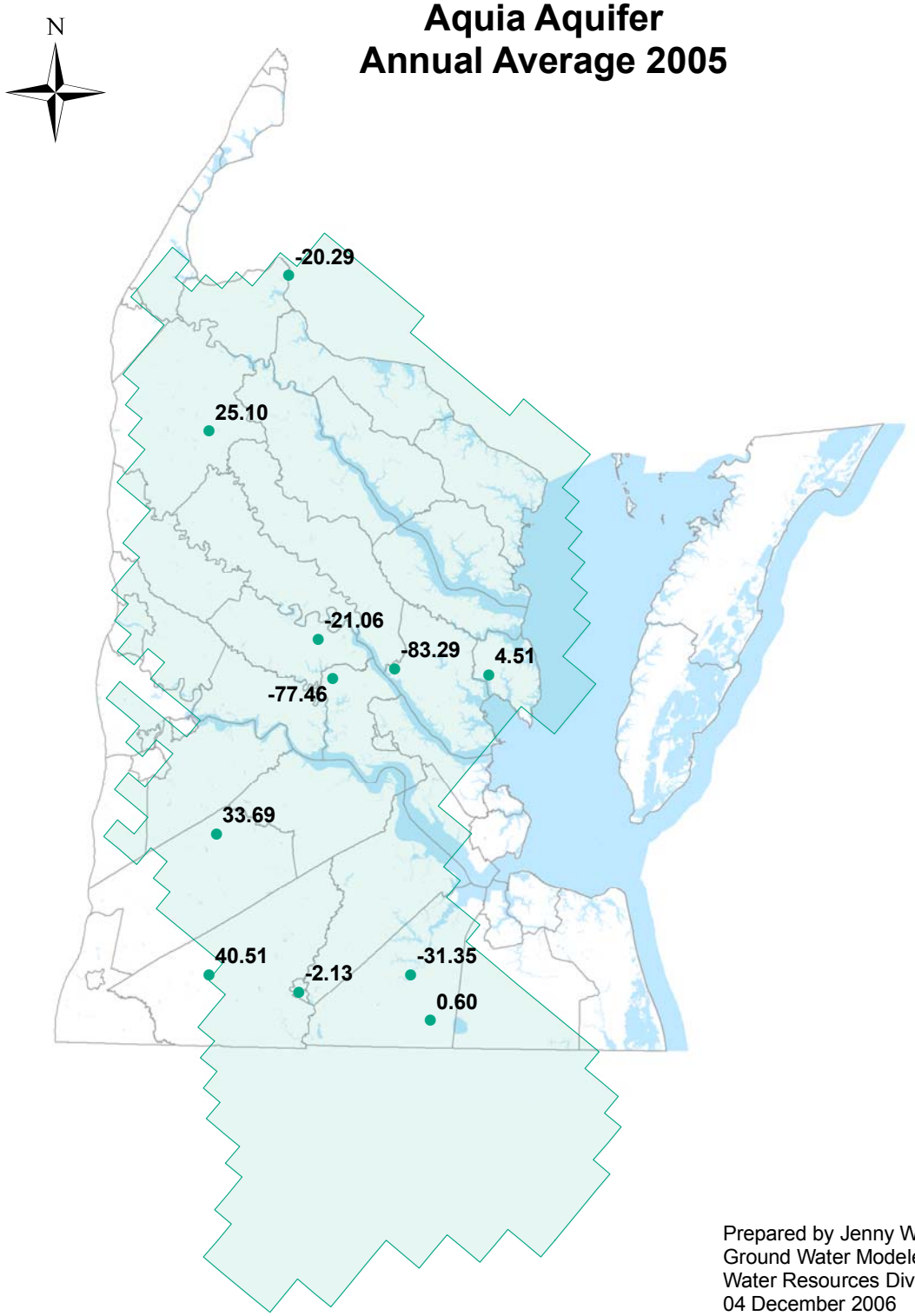
Averaged water level elevations for each observation well are in feet relative to mean sea level (msl).

0 10 20 40 60 80 Miles

Active Model Area for Upper Potomac Aquifer

Observed Water Levels
Aquia Aquifer
Annual Average 2005



Averaged water level elevations for each observation well are in feet relative to mean sea level (msl).

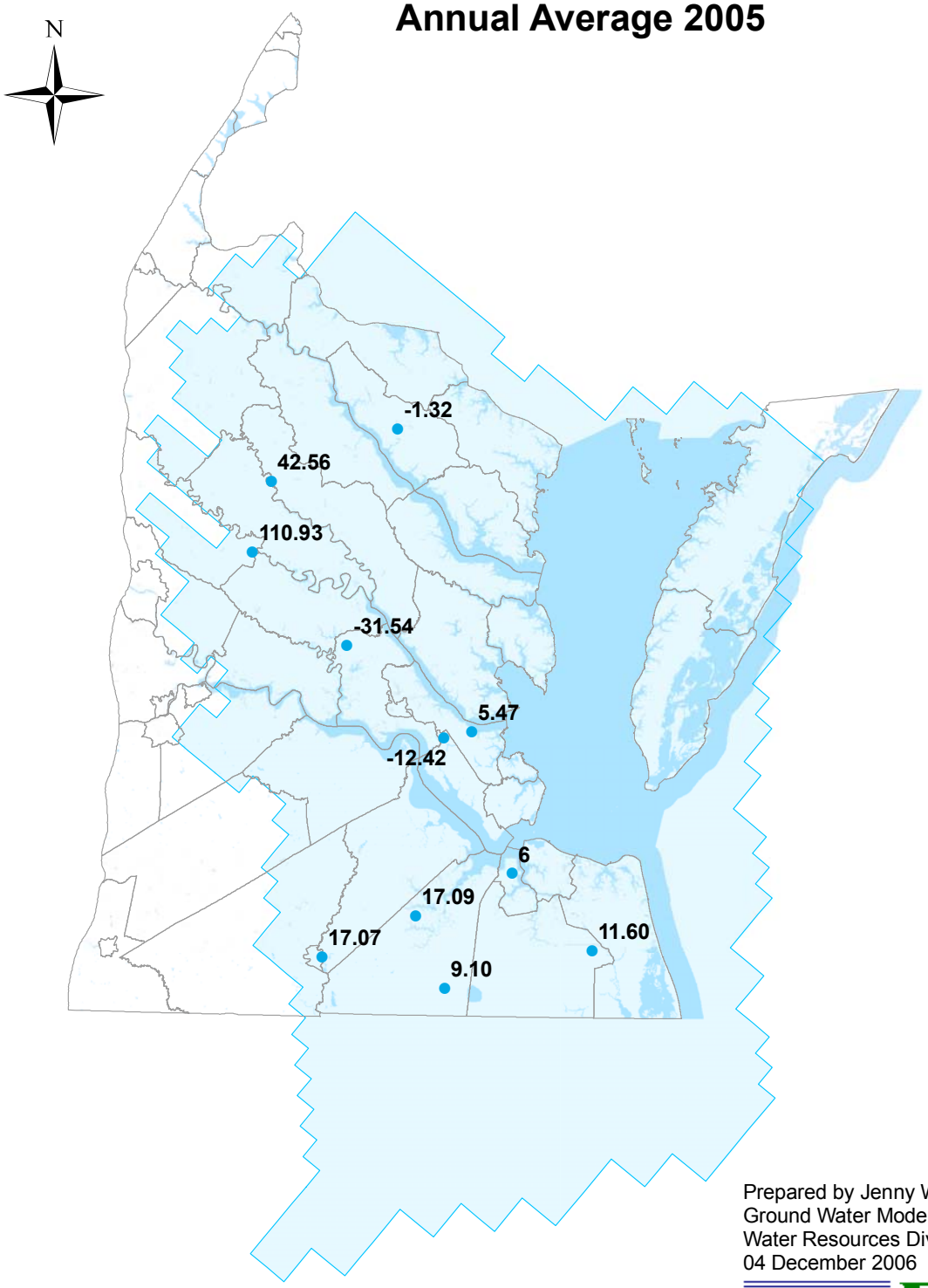
0 10 20 40 60 80 Miles

Active Model Area for Aquia Aquifer

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
04 December 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Observed Water Levels
Chickahominy-Piney Point Aquifer
Annual Average 2005



Averaged water level elevations for each observation well are in feet relative to mean sea level (msl).

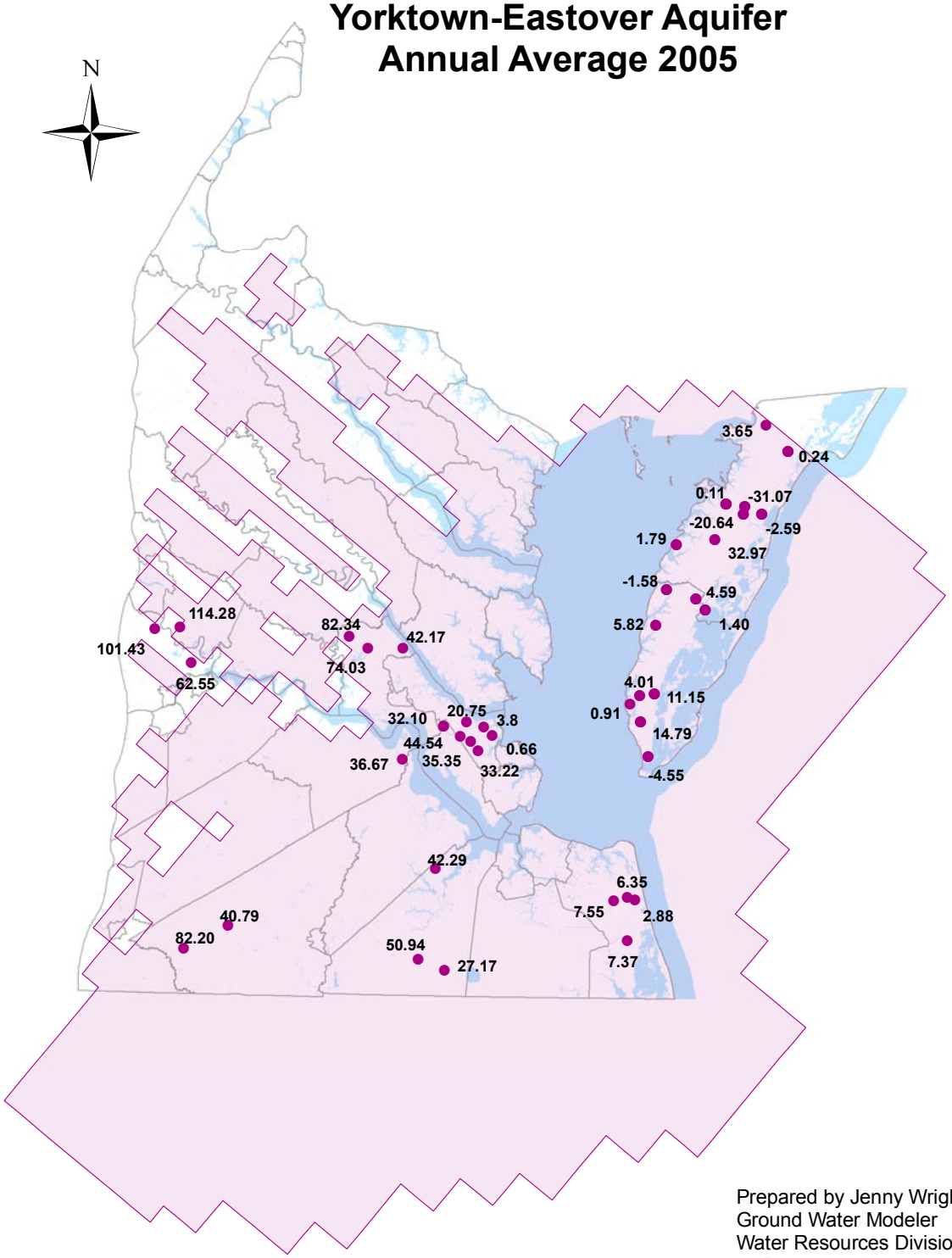
0 10 20 40 60 80 Miles

Active Model Area for Chickahominy-Piney Point Aquifer

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
04 December 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Observed Water Levels
Yorktown-Eastover Aquifer
Annual Average 2005



Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
04 December 2006

Averaged water level elevations for each observation well are in feet relative to mean sea level (msl).

0 10 20 40 60 80 Miles

Active Model Area for Yorktown-Eastover Aquifer

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Attachment C

Permits Simulated
2005 Total Permitted Use

PERMIT	OWNER	FACILITY	Permitted Q (gal/yr)
GW0000101	Hanover County of	Hanover Urban Water System	324,850,000
GW0000200	A R Tedesco	Desco Corporation	14,782,135
GW0000401	DuPont Teijin Films	DuPont Teijin Films	93,000,000
GW0000600	New Kent County of	Route 33 Corridor Water System	840,960,000
GW0000801	Claremont Town of	Claremont Town of Water System	17,100,000
GW0001000	Woodhaven Water Company Incorporated	Woodhaven Water Company Incorporated	50,000,000
GW0001200	Cedarwood Properties	Cedarwood Subdivision Water System	8,103,000
GW0001300	Delmarva Properties	New Kent Development Water System	607,338,100
GW0001401	Hanover County of	Georgetown	6,465,000
GW0001701	Hanover County of	Sinclair Manor	5,310,000
GW0001900	Hanover County of	Strawhorne	7,740,000
GW0002000	Sydnor Hydrodynamics Incorporated	Woodruff Public Water System	5,365,500
GW0002100	Sussex Service Authority	Northeastern Regional Water System	183,960,000
GW0002200	Cabell Associates	Woods Edge Dispatch Station Water System	12,400,000
GW0002300	Hanover County of	Hanover Courthouse	58,400,000
GW0002400	Sydnor Hydrodynamics Incorporated	Avondale Robin Ridge	38,311,000
GW0002600	Sydnor Hydrodynamics Incorporated	Walnut Grove	9,883,000
GW0002800	Sydnor Hydrodynamics Incorporated	Cherrydale	25,714,800
GW0002900	Sydnor Hydrodynamics Incorporated	Hanover Farms	12,017,500
GW0003000	Sydnor Hydrodynamics Incorporated	Rural Point	29,827,436
GW0003100	Sydnor Hydrodynamics Incorporated	Burnside Farms Mayfield Ellerson	30,279,700
GW0003200	Sydnor Hydrodynamics Incorporated	Colonial Forest	8,169,810
GW0003300	Sydnor Hydrodynamics Incorporated	High Point Farms	8,691,210
GW0003400	Sydnor Hydrodynamics Incorporated	Spring Meadows and Meadowgate Water System	79,417,800
GW0003500	Golden Cat Division of Ralston Purina	Golden Cat Division of Ralston Purina	31,449,600
GW0003600	Prince George County of	Rivers Edge	14,647,700
GW0003700	Sydnor Hydrodynamics Incorporated	Oak Springs Subdivision	19,844,940
GW0003800	Modern Hotel, LLC	Best Western Steven Kent	8,291,100
GW0003900	Virginia Power Innsbrook Technical Center	Surry Power Station	154,703,008
GW0004000	Prince George County of	Beechwood Manor	25,160,300
GW0004100	Prince George County of	Jordan on the James	23,652,000
GW0004200	Sydnor Hydrodynamics Incorporated	Colonial Court Eastover National Heights	28,366,000
GW0004300	Wakefield Town of	Wakefield Town of Municipal Water Supply System	54,613,460
GW0004400	King William County of Public Schools	Acquinton Elmtry School & Hmltn Holmes School	2,512,290
GW0004500	King William County	King William County - Central Garage Water System	25,039,000
GW0004600	Charles City County of	Wayside Well System	7,922,000
GW0004700	Prince George County of	Food Lion Industrial Water Supply	24,000,000
GW0004800	Whispering Winds LLC	Whispering Winds Mobile Home Park	5,295,260
GW0004900	Charles City County of	Mt Zion Rustic Public Water System	13,446,600
GW0005000	West Point Town of	West Point Public Water System	222,652,000
GW0005100	Smurfit-Stone Container Enterprises, Inc	West Point Mill Water System	8,407,200,000
GW0005200	US Army CASCOM and Fort Lee	Cardinal Golf Course at Fort Lee	50,000,000
GW0005500	Industrial Power Generating Company, LLC. (INGENCO)	INGENCO Charles City Peaking Facility	3,900,000
GW0005700	New Kent County of	Quinton Park Water System	5,365,500
GW0005800	New Kent County of	Quinton Estates	6,570,000
GW0006000	Surry County of Public Schools School Board	Surry County of Public Schools	4,200,000
GW0006100	Sun Pool 1 LLC	Pine Ridge Community	19,600,000
GW0006300	Department of Youth and Family Services	Hanover Learning Center	9,567,600
GW0030100	York County Department of Environmental Services	Lightfoot Water Supply System	204,400,000
GW0030200	Newport News City of Public Utilities	Newport News City of Waterworks Lee Hall	2,555,000,064

GW0030500	Bayville Golf Club	Bayville Golf Club	16,100,000
GW0030600	York County Department of Environmental Services	Skimino Hills Banbury Cross Water System	24,900,000
GW0030900	Batista Madonia Sr	East Coast Brokers and Packers	4,974,500
GW0031000	James City Service Authority	JCSA -Racefield Subdivision W 29	7,000,000
GW0031100	James City Service Authority	JCSA -Glenwood Acres Subdivision W 30	3,200,000
GW0031300	James City Service Authority	JCSA -Upper County Park W 35	5,800,000
GW0031400	James City Service Authority	JCSA -Ware Creek Manor Number 1 and 2 W 36	4,700,000
GW0031600	Virginia Commonwealth of DCR	Kiptopeke State Park	3,235,000
GW0031800	Smithfield Town of	Smithfield Town of	511,000,000
GW0032200	Suffolk City of Department of Public Utilities	Holland Water System	13,600,000
GW0032500	Isle of Wight Public Service Authority	Rushmere	13,000,000
GW0033000	Isle of Wight Public Service Authority	Smithfield Heights Sandy Mount Manor	11,700,000
GW0033500	Tidewater Water Company	Sedley Town of	10,800,000
GW0033700	National Linen and Uniform Service LLC	National Linen and Uniform Service LLC	43,000,000
GW0033800	Southampton County of	Agri Business Industrial Park	109,500,000
GW0033900	Integrated Fisheries International Limited	Integrated Fisheries International Limited	95,000,000
GW0034100	Valley Proteins Incorporated	Valley Proteins Incorporated Emporia Plant	15,603,000
GW0034200	KMX Chemical Corporation	KMX Chemical Corporation	76,440,400
GW0034300	BASF Corporation	BASF - Portsmouth Plant	153,300,000
GW0034400	Capital Concrete Incorporated	Capital Concrete Inc Stapleton Street Plant	9,951,240
GW0034700	Tidewater Area Central Hospital Laundry Inc	Shared Hospital Services	28,304,000
GW0034800	Broad Bay Country Club	Broad Bay Country Club	19,100,000
GW0035100	BASF Corporation	BASF Corporation	1,297,200,000
GW0035400	Onancock Town of	Onancock Town of	61,000,000
GW0036100	Colonial Williamsburg Foundation	Colonial Williamsburg -New Golf Course	49,000,000
GW0036200	Courtland Town of	Courtland Town of	58,900,000
GW0036300	Cogentrix Virginia Leasing Corporation	Cogentrix Virginia Wells A thru F	949,000,000
GW0036500	Bayshore Concrete Products -Chesapeake	Bayshore Concrete Products/Chesapeake	8,400,000
GW0036800	Sanifill of Virginia Incorporated	Big Bethel Landfill	137,708,000
GW0037000	James River Country Club	James River Country Club	11,600,000
GW0037300	Shore LifeCare Incorporated	Shore LifeCare at Parksley	6,800,000
GW0037400	Cintas Corporation	Cintas of Portsmouth	23,600,000
GW0037500	Norfolk City of Department of Utilities	Norfolk City of Utilities Four Suffolk Wells	5,818,500,096
GW0037600	Hercules Incorporated	Hercules Incorporated	2,433,900,032
GW0037700	Williamsburg City of	Williamsburg City of -number 1	258,100,000
GW0037900	Bayshore Concrete Products -Cape Charles	Bayshore Concrete Products Corp Cape Charles	27,700,000
GW0038100	Ciba Specialty Chemicals Incorporated	Ciba Specialty Chemicals Corp.	32,200,000
GW0038200	Trails End Utility Company Incorporated	Trails End Utility Company Incorporated	15,700,000
GW0038800	Exmore Town of	Exmore Town of	60,800,000
GW0039000	Richmond Cold Storage Incorporated	RCS Smithfield Incorporated	11,700,000
GW0039200	Shore Landvest Incorporated	Best Western Sunset Beach Resort	7,650,000
GW0039300	US NASA -Wallops Flight Facility	US NASA -Goddard Space Flight Center Island Systems	13,300,000
GW0039500	Southampton County of	Branchville Boykins	88,200,000
GW0039600	Southampton County of	Drewryville	6,300,000
GW0039700	Southampton County of	Edgehill	15,400,000
GW0039900	C and P Water Company - IOW	Ashby Subdivision Water System	21,600,000
GW0040100	VDOC -Eastern Region	VDOC -Saint Brides Correctional Center	193,000,000
GW0040300	Elizabeth Manor Golf and Country Club	Elizabeth Manor Golf and Country Club	18,980,000
GW0040400	US Navy -Norfolk Naval Base	Sewells Point Golf Course	14,000,000
GW0040500	US Navy Commander Naval Base Norfolk	Oceana Golf Club Ballfields and Car Wash	108,000,000
GW0040700	Southeastern Public Service Authority	Regional Landfill	10,500,000
GW0040800	Aqua Virginia, Inc.	Indian River Water Company	87,000,000
GW0040900	TCS Materials	Gilmerton Plant	12,000,000

GW0041200	Cape Charles Town of	Cape Charles Municipal Corporation	252,200,000
GW0041300	Colonial Williamsburg Foundation	Colonial Williamsburg	672,899,968
GW0041400	Tournament Players Club of Virginia Beach Inc	PGA Tour TPC of Virginia Beach	82,000,000
GW0041500	Heron Ridge Golf Club	Heron Ridge Golf Club	48,500,000
GW0041700	American Golf Corporation	Chesapeake Golf Club	37,600,000
GW0041800	Murro Chemical Company Incorporated	Murro Chemical Company Incorporated	4,200,000
GW0041900	Wallace Cahoon	Cahoon Plantation	62,000,000
GW0042000	International Paper Company	Franklin Virginia Mill	13,390,000,128
GW0042100	Smithfield Foods Incorporated	Gwaltney of Smithfield Limited	568,700,032
GW0042200	Smithfield Foods Incorporated	Smithfield Packing Company	893,200,000
GW0042300	C and P Water Company - Suffolk	Scottswood Subdivision	20,000,000
GW0042500	YMCA of South Hampton Roads	YMCA Family Campground	5,500,000
GW0042600	Isle of Wight Public Service Authority	Southern Development Service District	357,700,000
GW0042700	Windsor Town of	Windsor Public Water System	197,000,000
GW0042800	Siemens Automotive Corporation	Siemens Newport News	38,360,000
GW0042900	Franklin City of	Franklin Water System	1,051,200,000
GW0043000	James City Service Authority	JCSA -The Retreat	5,677,940
GW0043100	VDOC -Eastern Region	VDOC -Southampton Correctional Complex	110,000,000
GW0043200	Southampton County of	Newsoms Town of	34,150,000
GW0043300	Commonwealth Chesapeake Company LLC	Commonwealth Chesapeake Power Station	61,400,000
GW0043400	James City Service Authority	JCSA -Central System	3,267,000,000
GW0043500	Narricot Industries Incorporated	Narricot Industries Inc Boykins Narrow Fab	55,100,000
GW0043600	White Tail Park	White Tail Park	4,500,000
GW0043700	Eastern Shore Yacht and Country Club	Eastern Shore Yacht and Country Club	25,000,000
GW0043800	David B Tankard	Davids Nursery	150,000,000
GW0043900	Chesapeake City of Public Utilities Department	Northwest River/Western Branch Systems	4,015,000,000
GW0044000	Virginia Beach City of	Kempsville Greens Golf Course	10,460,000
GW0044100	Titan Virginia Ready-Mix LLC	Port Norfolk Plant	5,000,000
GW0044300	Titan Virginia Ready-Mix LLC	Campostella Ready Mix Plant	9,100,000
GW0044400	Southampton Group	Southampton Mobile Home Park	34,000,000
GW0044500	Titan Virginia Ready-Mix LLC	Oceana Plant	3,100,000
GW0044700	Kinder Morgan Bulk Terminals	Pier IX Terminal Company	42,570,000
GW0044800	Titan Virginia Ready-Mix LLC	Rip Rap Road Ready Mix Plant Well 1 2 and 3	6,481,000
GW0045000	James City Service Authority	JCSA -Kings Village Subdivision W 31	5,300,000
GW0045100	Southern Concrete Products LLC	Money Point Plant	4,600,000
GW0045200	Bracey Enterprises Clydes Dale Mobile Home Park	Clydes Dale Mobile Home Park	15,000,000
GW0045300	Nottingham Enterprises Incorporated	Herbert Nottingham Farm (Cheapside)	10,650,000
GW0045400	Eastville Town of	Eastville Town of	23,700,000
GW0045500	Dominion Terminal Associates	Dominion Terminal Associates	53,800,000
GW0045600	Charles D Tankard	Tankard Farm	52,000,000
GW0045700	Emily Rae Heflen	Drummond Farm	31,000,000
GW0045800	Western Tidewater Water Authority	Western Tidewater Water Authority	3,045,770,000
GW0045900	C and P Water Company - IOW	Brewers Creek Subdivision	12,500,000
GW0046000	Ballard Brothers Fish Company Incorporated	Cherrystone Family Camping Resort	11,100,000
GW0046200	Accomack County	Accomack County Office Buildings Waterworks	5,453,000
GW0046300	Virginia Landings - National American Corporation	Virginia Landing Campground	8,000,000
GW0046400	Isle of Wight Public Service Authority	Days Point	6,800,000
GW0046500	Gwaltney of Smithfield Limited	Smithfield Ham and Products Inc	10,000,000
GW0046600	Cavalier Golf and Yacht Club	Cavalier Golf and Yacht Club	23,000,000
GW0046700	Princess Anne Country Club	Princess Anne Country Club	26,430,000
GW0046800	Virginia Department of Veterans Services	Albert G. Horton, Jr. Memorial Veterans Cemetery	6,700,000
GW0046900	Titan Virginia Ready-Mix LLC	Skiffes Creek Plant	7,410,000
GW0047200	US DOE - Thomas Jefferson National Accelerator Facility	Thomas Jefferson National Accelerator Facility	7,074,000

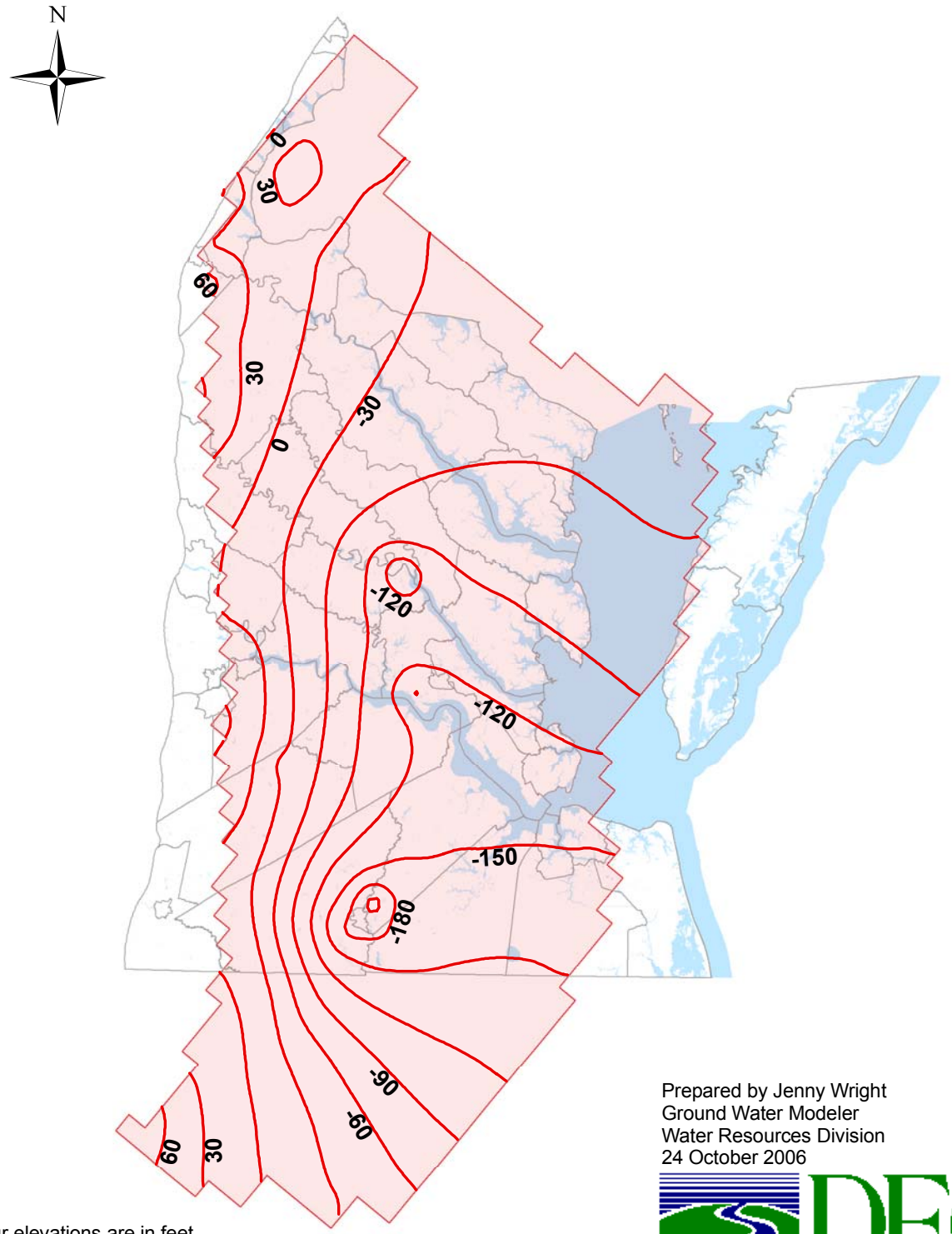
GW0047700	Alsco Incorporated	Servitex Division of Alsco	18,700,000
GW0047800	Busch Entertainment Operations Department	Busch Gardens Williamsburg Operations Dept	47,000,000
GW0047900	Shore Health Services, Inc.	Shore Memorial Hospital	37,110,000
GW0048700	Williamsburg Pottery Factory	Williamsburg Pottery Factory	6,580,000
GW0048800	Williamsburg Pottery Factory	Williamsburg Pottery Factory	9,871,000
GW0049400	James City Service Authority	JCSA -Wexford Hills Subdivision	14,000,000
GW0050700	SHODON	Mobile Estates	4,000,000
GW0060000	Norfolk City of Nursery	Norfolk City of Nursery	2,600,000
GW0060100	Lancaster Farms Incorporated	Lancaster Farms Incorporated	11,300,000
GW0061700	Taylor and Fulton Inc.	Lewis Farm	24,300,000
GW0061800	Taylor and Fulton Inc.	Sommers Farm	24,300,000
GW0061900	Bruce H Richardson	Belote Farm	16,200,000
GW0062000	George W. Turner Real Estate Trust	James Wharf Farm	17,000,000
GW0062100	Charles D Tankard	Wyatt Farm	15,200,000
GW0060200	William Earl Dennis	Dennis Nursery	5,000,000
GW0060300	William Earl Dennis	Dennis Azaleas	2,700,000
GW0060400	Tankard Nurseries LLC	Lumber Hall Farm	51,400,000
GW0060500	Eleanor Bull Lambertson	C and H Farms Incorporated	15,300,000
GW0060600	Long Grain & Livestock Co / David Long	Midwood Farm	22,800,000
GW0060700	Zieger Floral, Incorporated	Edgehill Farm	7,300,000
GW0060900	Ronald Bailey	Twin Cedar Farms	22,100,000
GW0061000	Lynwood M Guy	Guy Produce Farms	24,800,000
GW0061100	William M Daley	Broadleaf Farms	3,700,000
GW0061200	Glenn P Sterling	Nursery Growers	1,800,000
GW0061400	George T Sharp	Edgewater Farm	13,400,000
GW0061600	Taylor and Fulton Inc.	Gillespe Farm	28,000,000
GW0062200	Gordon L Sturgis	Liberty Hall Farm	4,400,000
GW0062300	C James Prettyman III	Silver Beach Farm	5,500,000
GW0062400	Agnes B Willard	Painter Farm	1,400,000
GW0062500	Robert Van Dessel	Robert Van Dessel Farm	3,400,000
GW0062600	David Van Dessel	David Van Dessel Farm	4,500,000
GW0062800	Ace 1971 and Gigi 1971 Trust	Hogneck Farm	13,000,000
GW0062900	Ace 1971 and Gigi 1971 Trust	Hagan Farm	17,000,000
GW0063000	500 Group, LLC	Bobtown Nursery	10,900,000
GW0063100	Richard F Hall III	Weaver Farm	32,900,000
GW0063200	Donald L Fitchett	Home Farm	8,400,000
GW0063300	Richard F Hall III	James Farm	54,000,000
GW0063400	Richard F Hall III	Rew Farm	49,000,000
GW0063600	Richard F Hall III	Gunter Farm	12,500,000
GW0063700	Nell Thomas, Pres. c/o Dorothy Nell Thomas, VP	Ames Farm	65,000,000
GW0063800	Nell Thomas, Pres. c/o Dorothy Nell Thomas, VP	Middleton Farm	185,000,000
GW0063900	Kuzzens Incorporated	Grapeland Farm	31,100,000
GW0064000	Kuzzens Incorporated	Marshall/Johnson Farm	36,100,000
GW0064100	Turner Limited Land Partnership c/o James A Turner Jr	Holts Neck Farm	23,000,000
GW0064200	Greenbrier Farms Incorporated	Greenbrier Farms Nursery	88,200,000
GW0064300	BAR-RAB, L.L.C.	Kelley Farm	30,124,000
GW0064400	Ellen Wessells	Wessells Farm	21,517,000
GW0064500	Virginia Department of Conservation and Recreation	Mutton Hunk Fen Natural Area Preserve	40,340,000
GW0064600	Byrd Foods Incorporated	Al Wessells Bob Watkinson	13,500,000
GW0064700	Byrd Foods Incorporated	Northam Somers	37,800,000
GW0064800	Byrd Foods Incorporated	Ed Goin	34,320,000
GW0064900	Byrd Foods Incorporated	Lang	51,840,000
GW0065000	Byrd Foods Incorporated	AL Matthews	41,904,000

GW0065100	Alice Russell	Hickory Hill	34,560,000
GW0065200	Byrd Foods Incorporated	Wes Powers	20,160,000
GW0065300	Byrd Foods Incorporated	Bethel Church	32,400,000
GW0065500	Byrd Foods Incorporated	Peach Orchard	42,600,000
GW0065600	Kuzzens Incorporated	Bowen Farm	42,620,000
GW0065700	Kuzzens Incorporated	Machipongo Farm	48,800,000
GW0065800	Kuzzens Incorporated	Painter Farm	18,400,000
GW0065900	Kuzzens Incorporated	Christian/Ames Farm	56,091,000
GW0066000	Kuzzens Incorporated	Melfa Farm	30,360,000
GW0066100	Murphy Brown LLC	Smithfield Carroll's Farms 1 thru 5	54,120,000
GW0066200	Murphy Brown LLC	Smithfield Carroll's Farm 6-8	30,316,000
GW0066300	Murphy Brown LLC	Smithfield Carroll's Farms - 9,10 & 21	35,013,000
GW0066400	Murphy Brown LLC	Smithfield Carroll's Farm 12	11,103,000
GW0066500	Murphy Brown LLC	Smithfield Carroll's Farms - 13 & 14	18,656,000
GW0066600	Murphy Brown LLC	Smithfield Carroll's Farm - 15	9,598,000
GW0066700	Murphy Brown LLC	Smithfield Carroll's Farms - 16 & 17	20,075,000
GW0066800	Murphy Brown LLC	Smithfield Carroll's Farm 18	9,568,000
GW0066900	Murphy Brown LLC	Smithfield Carroll's Farms -19 & 20	20,330,000
GW0067000	Murphy Brown LLC	Smithfield Carroll's Farms - Feedmill	7,921,000
GW1030000	James City Service Authority	JCSA -Stonehouse W 25 W 26	262,800,000

Attachment D

Simulated Potentiometric Contours
2005 Total Permitted Use

Simulated Potentiometric Contours
Lower Potomac Aquifer
2005 Total Permitted Use



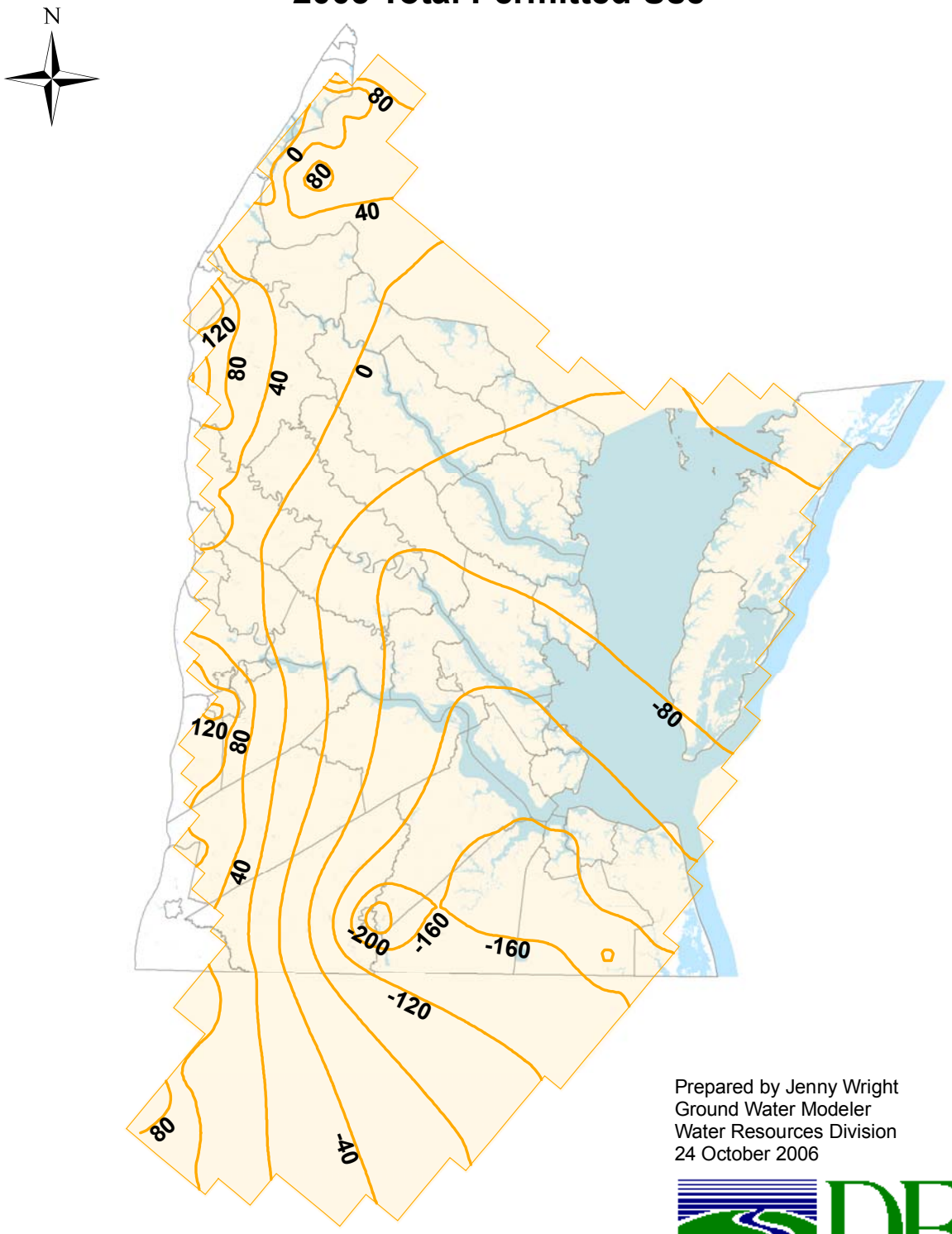
Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

0 20 40 80 Miles

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
Middle Potomac Aquifer
2005 Total Permitted Use



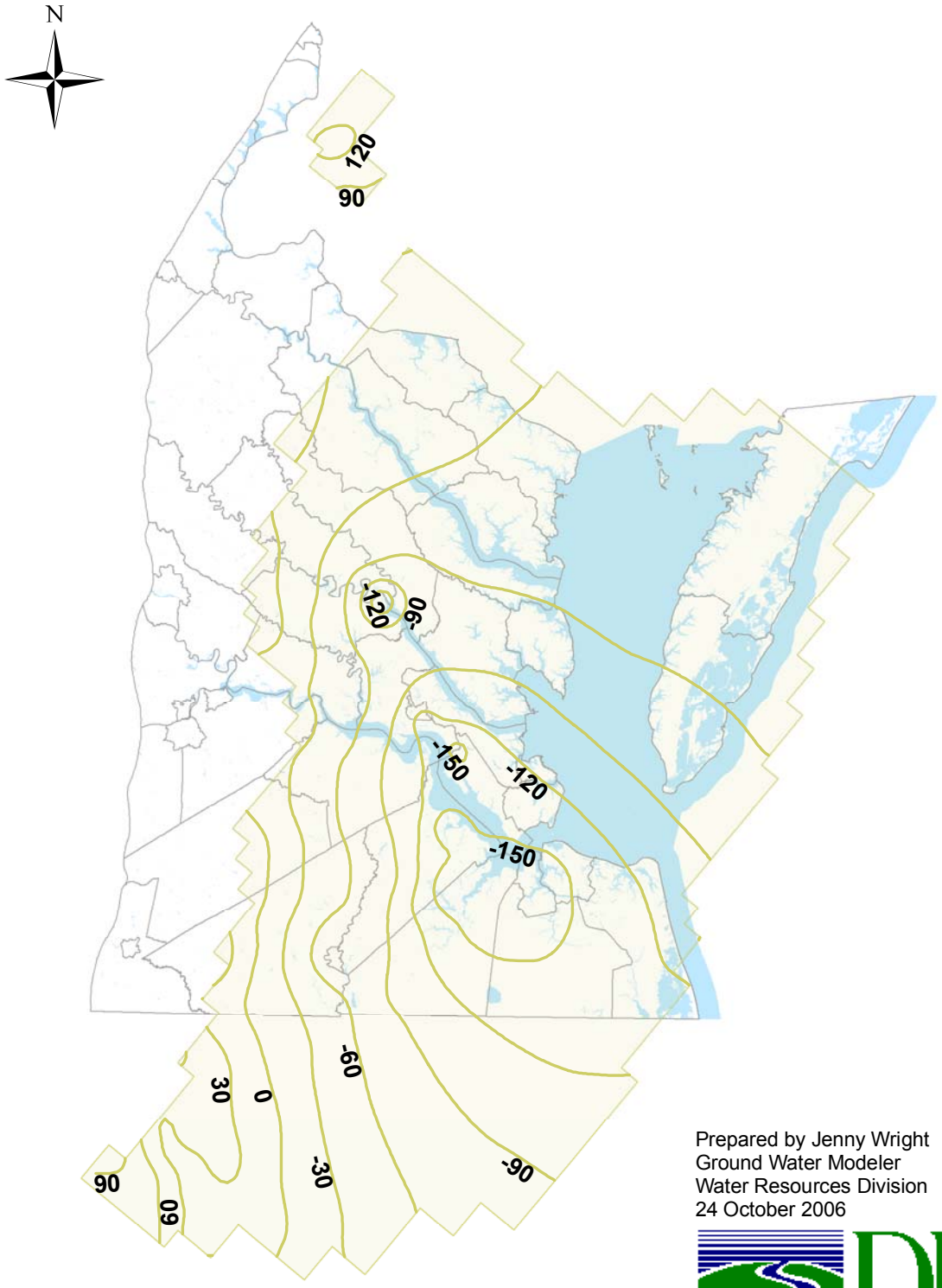
Contour elevations are in feet relative to mean sea level (msl) and at 40 ft intervals.

0 10 20 40 60 80 Miles

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
Upper Potomac Aquifer
2005 Total Permitted Use



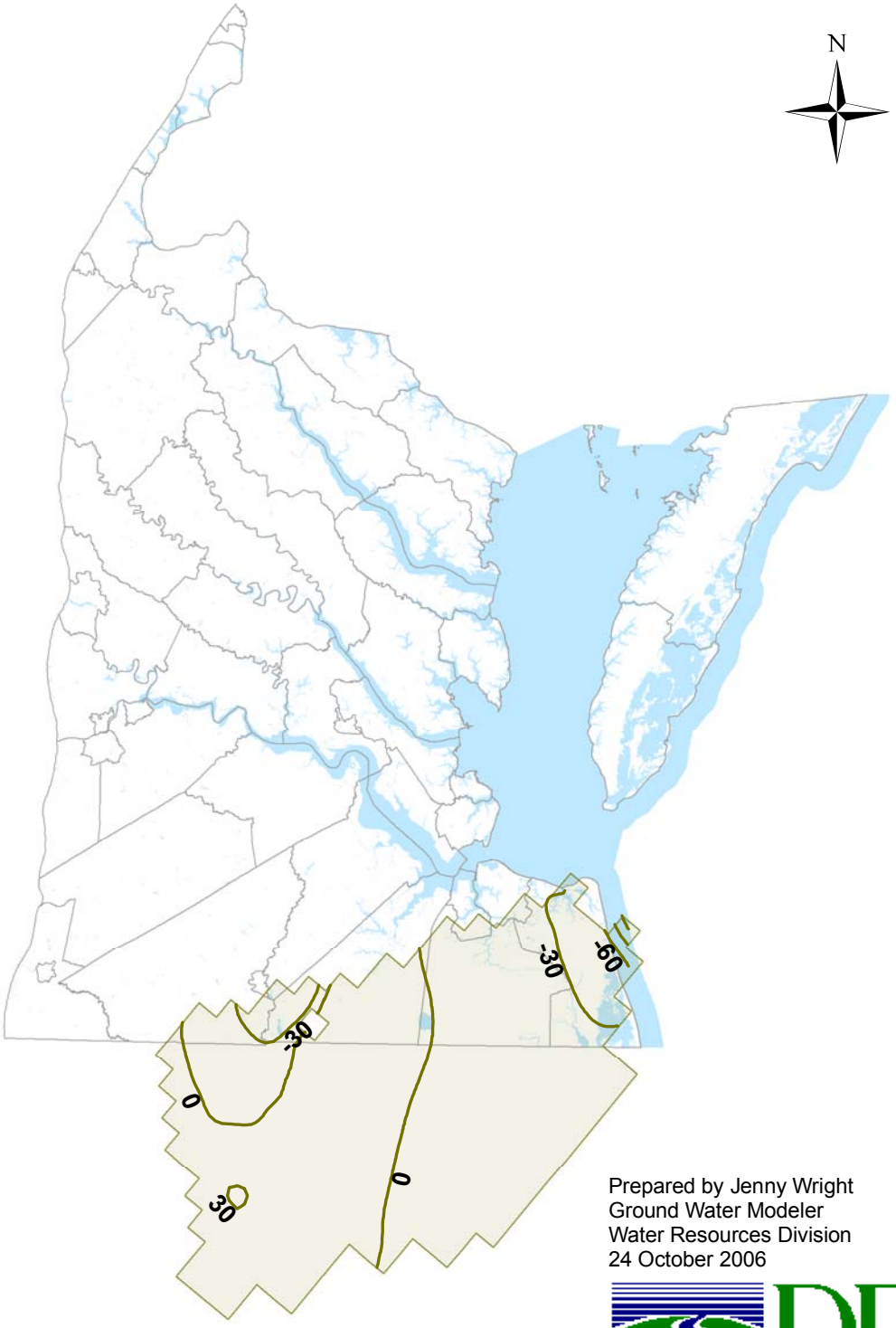
Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
Virginia Beach Aquifer
2005 Total Permitted Use



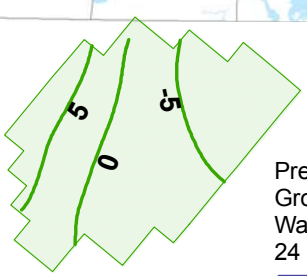
Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

DEQ
VIRGINIA DEPARTMENT OF
ENVIRONMENTAL QUALITY

Contour elevations are in feet relative to
mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80
Miles

Simulated Potentiometric Contours
Pee Dee Aquifer
2005 Total Permitted Use



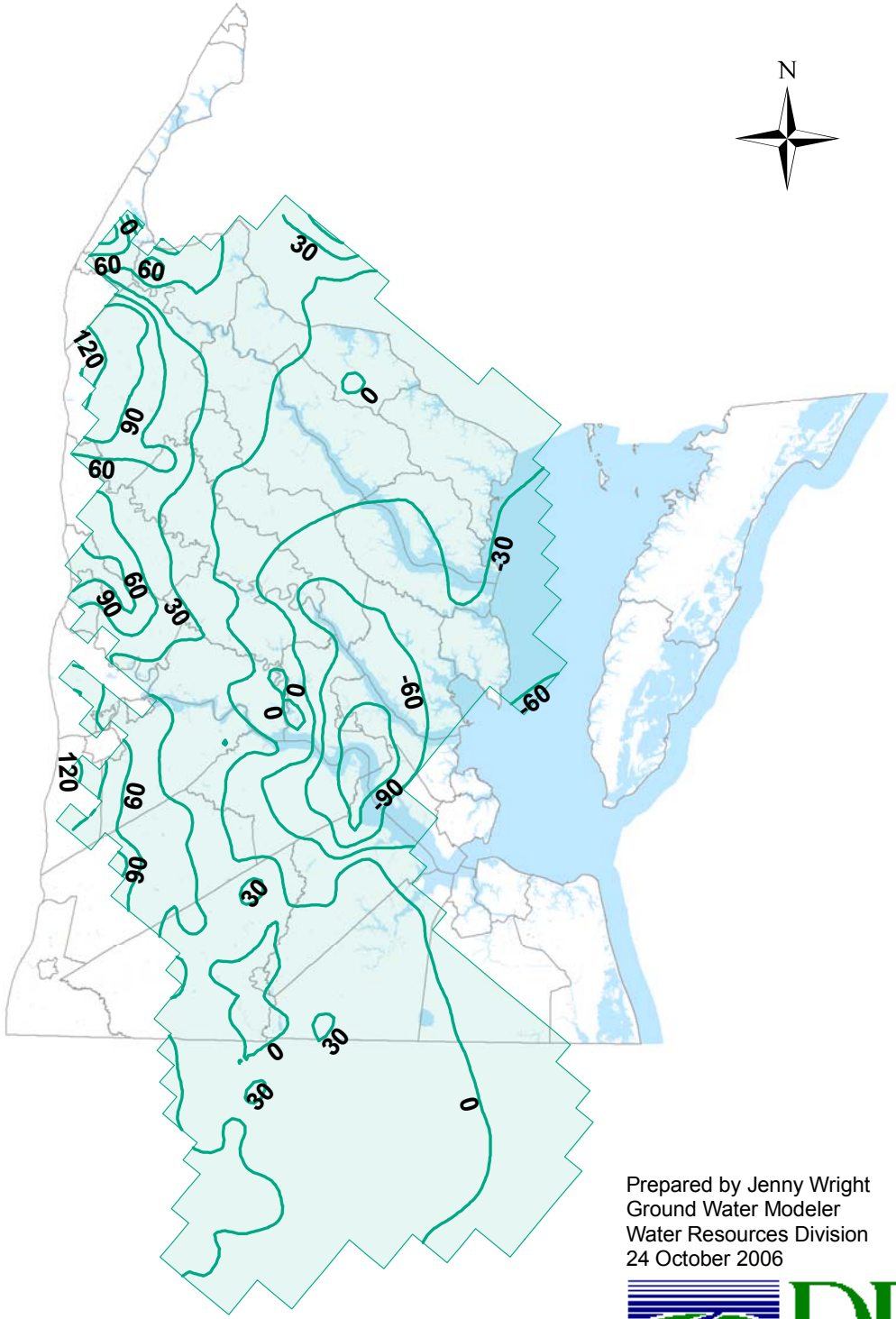
Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

Contour elevations are in feet relative to mean sea level (msl) and at 5 ft intervals.

0 10 20 40 60 80 Miles

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
Aquia Aquifer
2005 Total Permitted Use



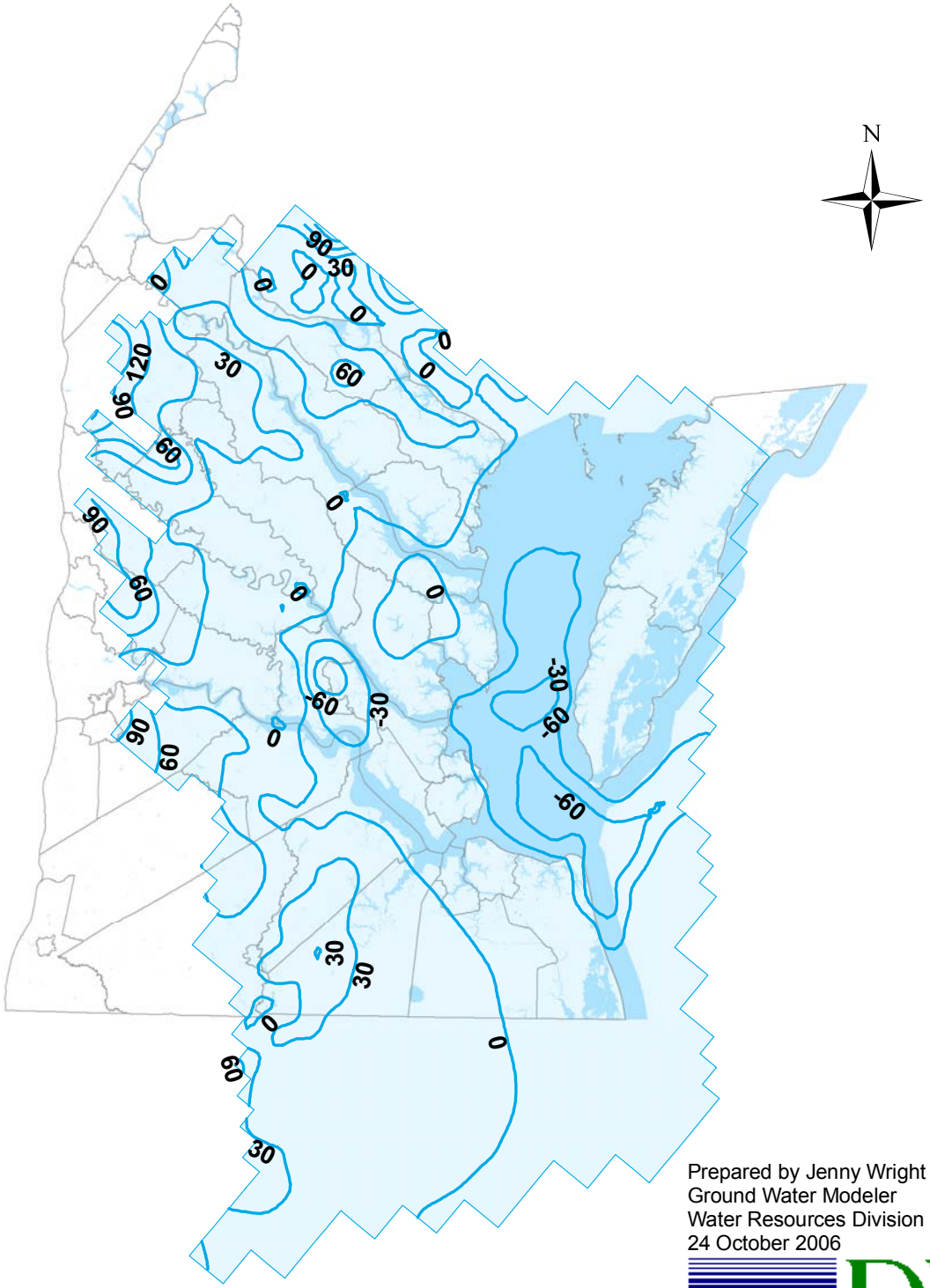
Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Simulated Potentiometric Contours
Chickahominy-Piney Point Aquifer
2005 Total Permitted Use



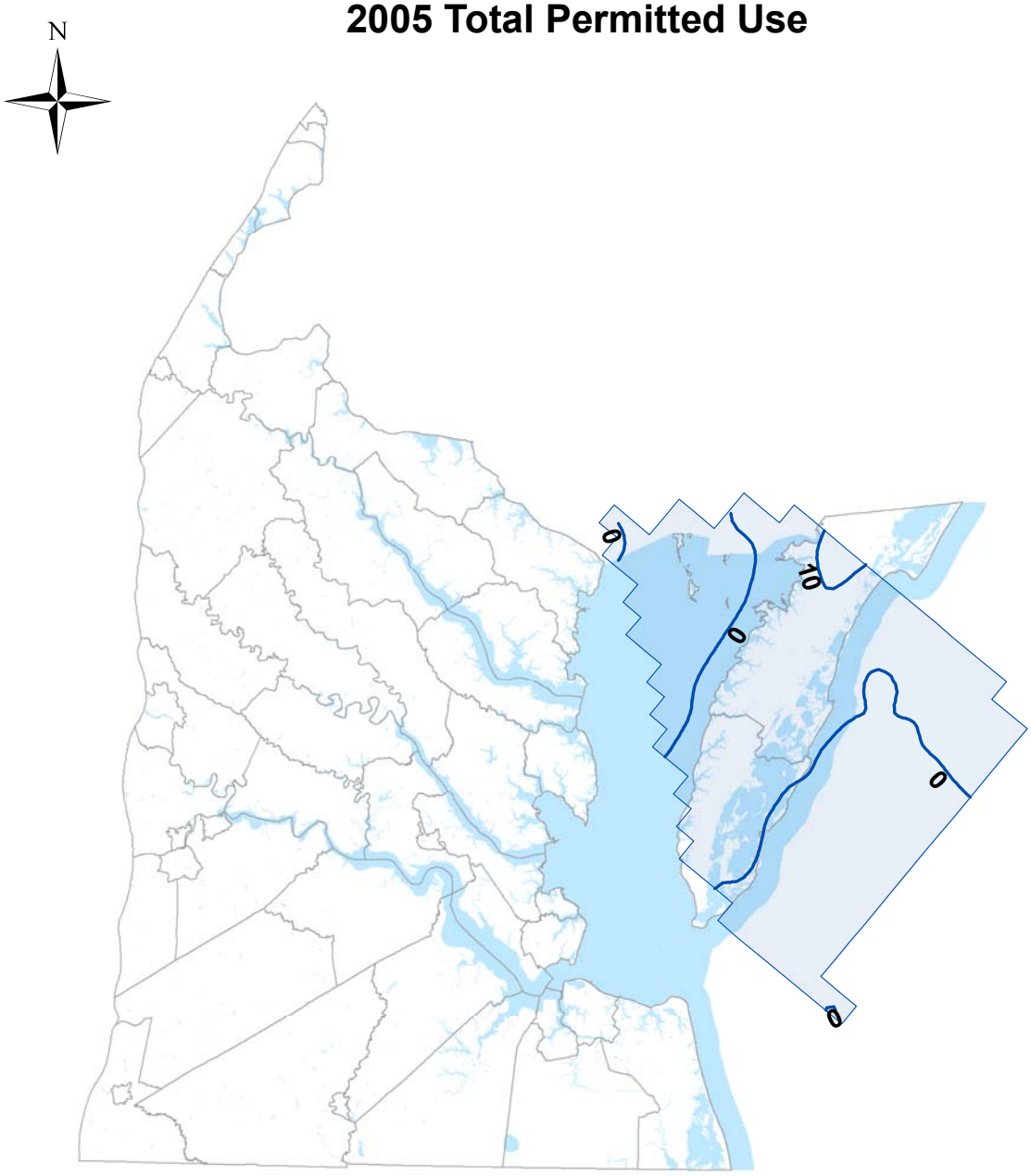
Contour elevations are in feet relative to mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Simulated Potentiometric Contours
St. Mary's Choptank Aquifer
2005 Total Permitted Use



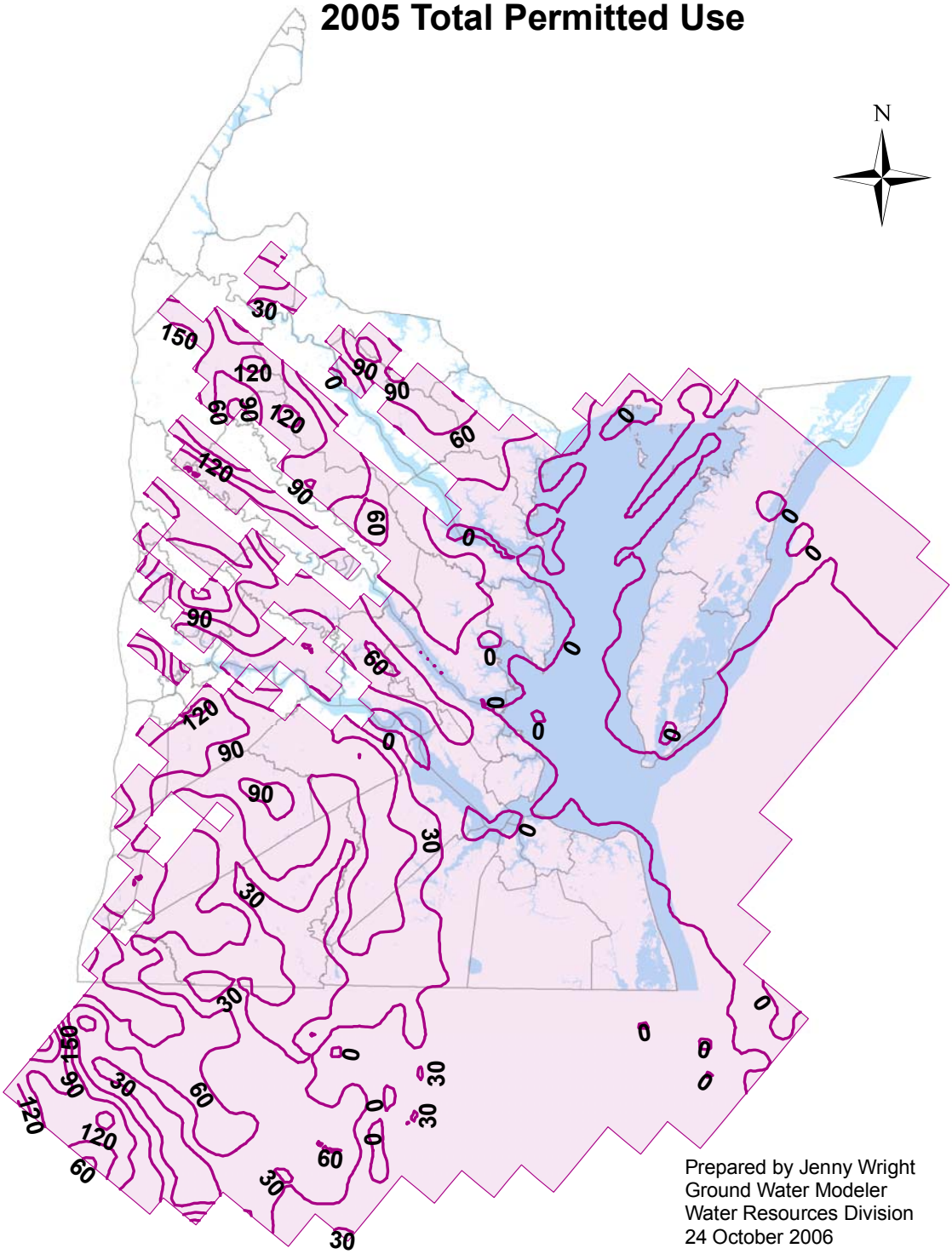
Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

DEQ
VIRGINIA DEPARTMENT OF
ENVIRONMENTAL QUALITY

Contour elevations are in feet relative to
mean sea level (msl) and at 10 ft intervals.

0 10 20 40 60 80 Miles

Simulated Potentiometric Contours
Yorktown-Eastover Aquifer
2005 Total Permitted Use



Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
24 October 2006

DEQ
VIRGINIA DEPARTMENT OF
ENVIRONMENTAL QUALITY

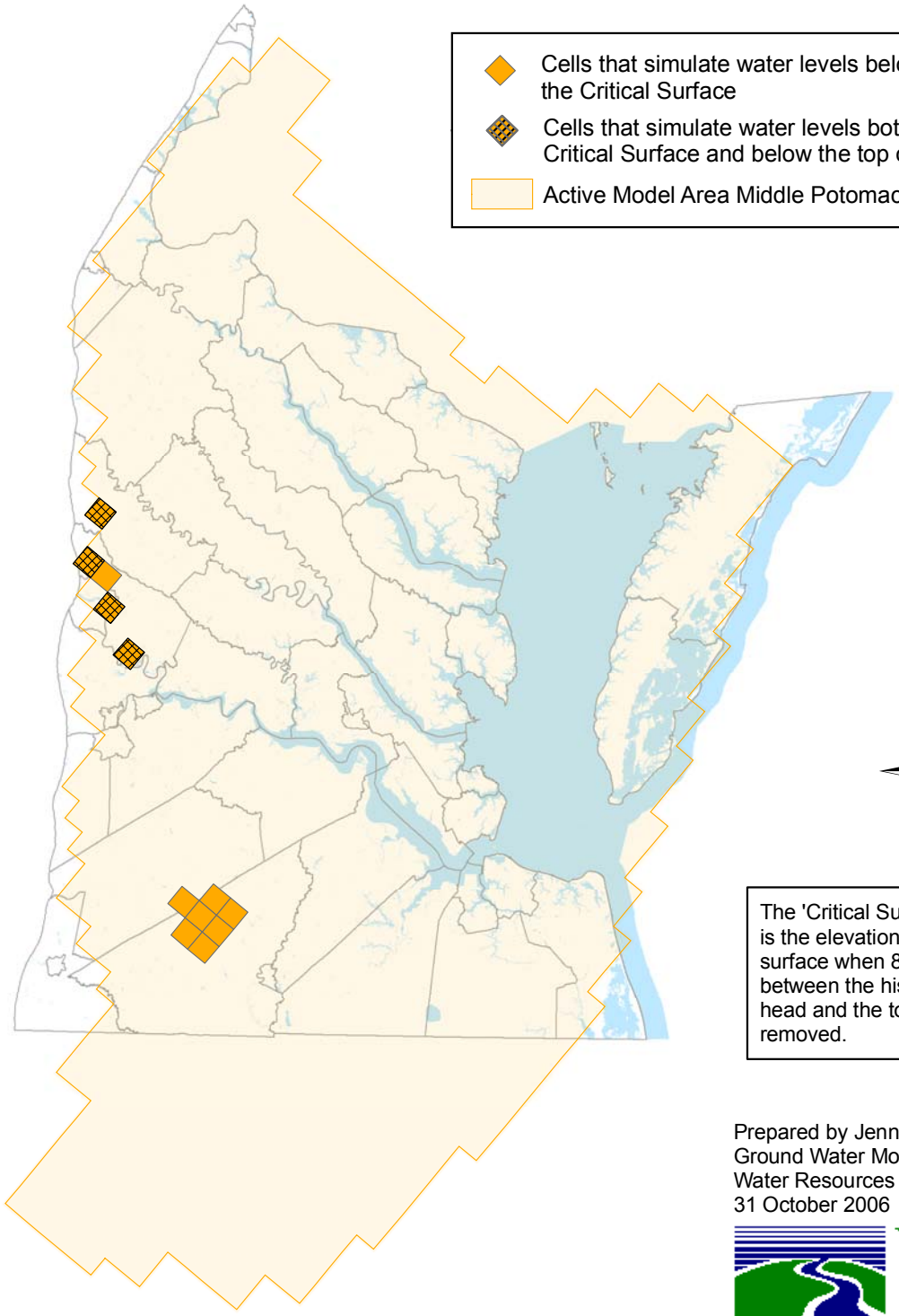
Contour elevations are in feet relative
to mean sea level (msl) and at 30 ft intervals.

0 10 20 40 60 80 Miles

Attachment E

Simulated Water Levels
Below Critical Surface and Below Aquifer Top

2005 Total Permitted Use - Middle Potomac Aquifer
Simulated Water Levels
Below Critical Surface and Below Aquifer Top

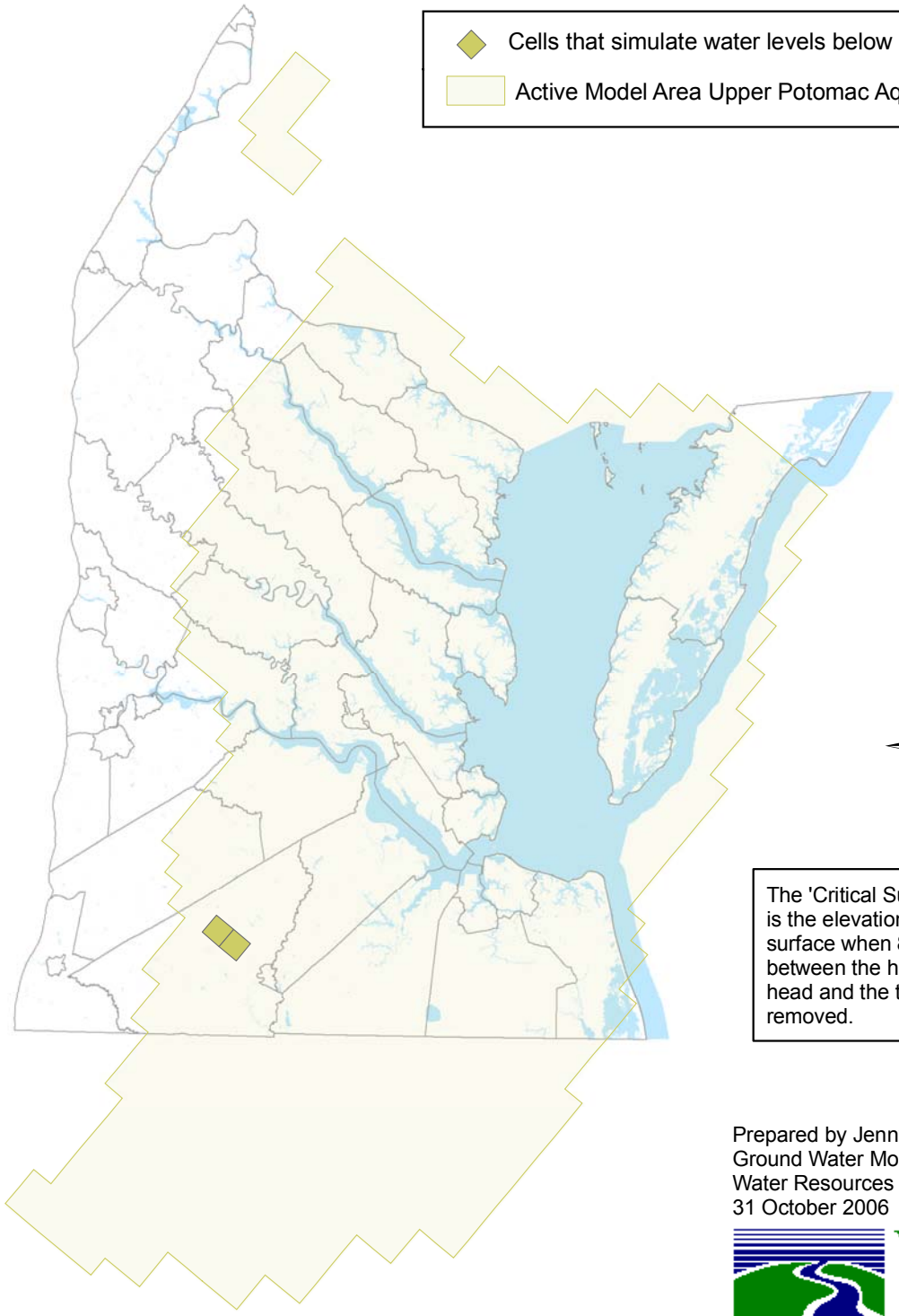


The 'Critical Surface' of an aquifer is the elevation of the potentiometric surface when 80% of the distance between the historic prepumping head and the top of the aquifer is removed.

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
31 October 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

2005 Total Permitted Use - Upper Potomac Aquifer
Simulated Water Levels
Below Critical Surface and Below Aquifer Top

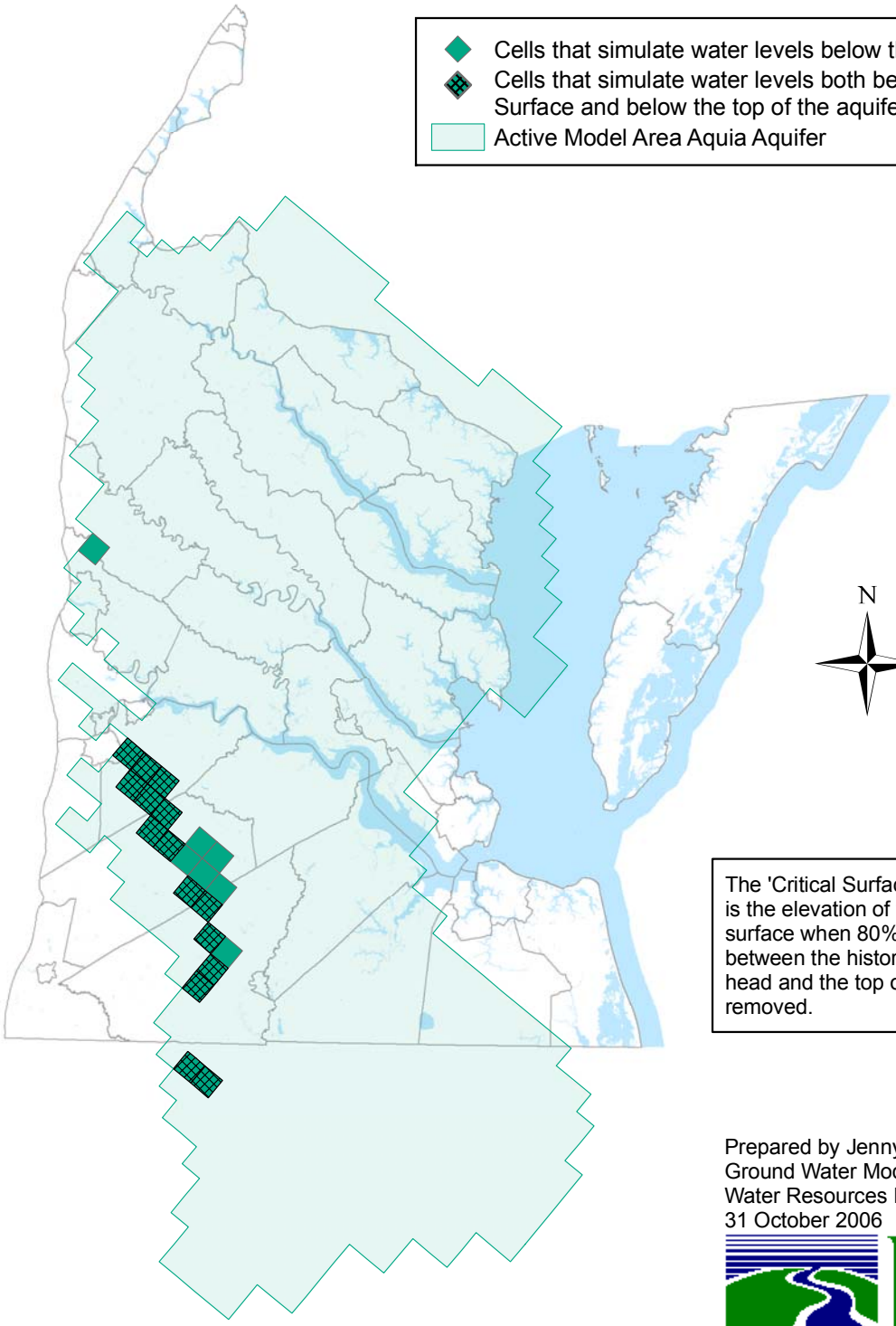


The 'Critical Surface' of an aquifer is the elevation of the potentiometric surface when 80% of the distance between the historic prepumping head and the top of the aquifer is removed.

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
31 October 2006

DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

2005 Total Permitted Use - Aquia Aquifer
Simulated Water Levels
Below Critical Surface and Below Aquifer Top

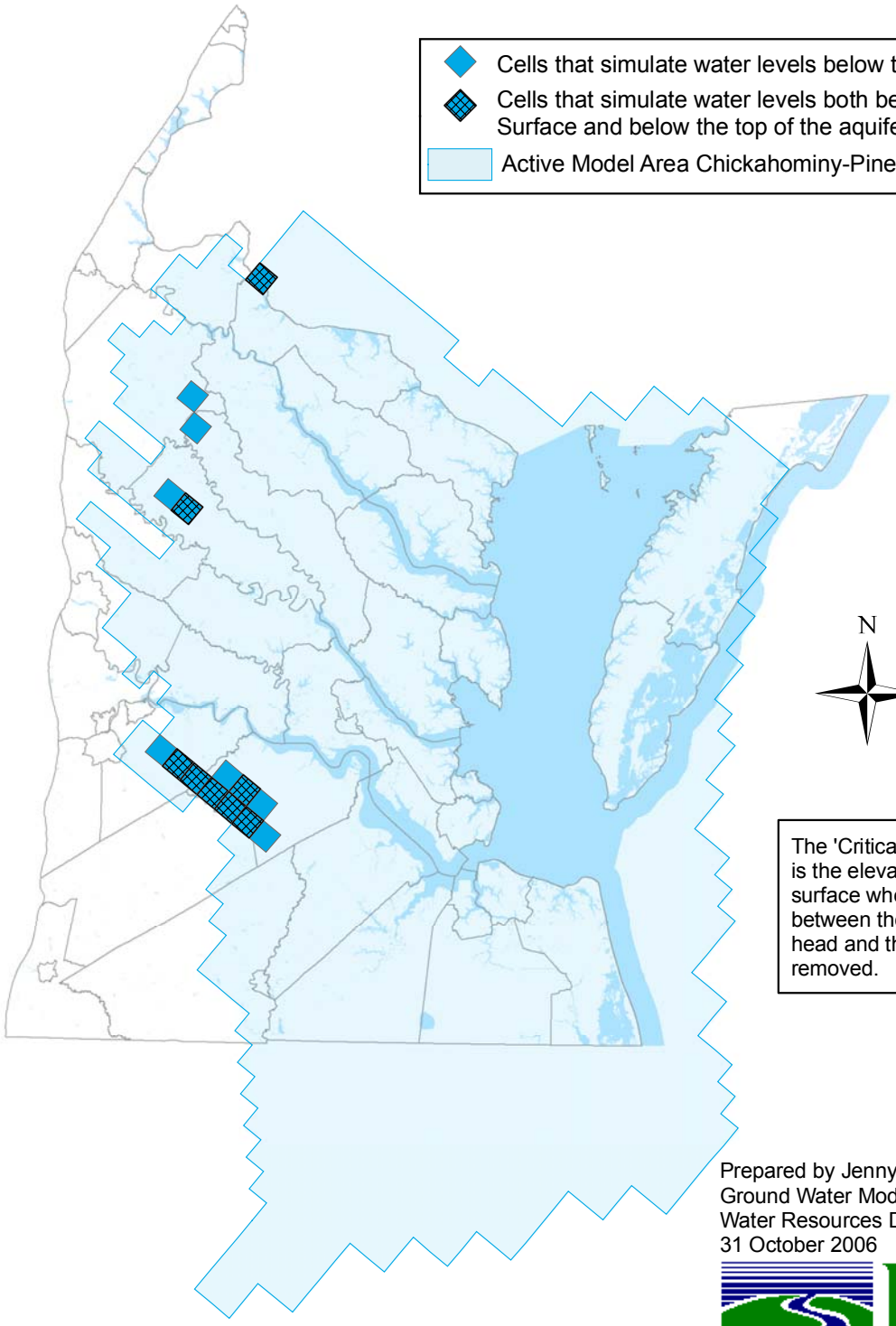


The 'Critical Surface' of an aquifer is the elevation of the potentiometric surface when 80% of the distance between the historic prepumping head and the top of the aquifer is removed.

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
31 October 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

2005 Total Permitted Use - Chickahominy-Piney Point Aquifer
Simulated Water Levels
Below Critical Surface and Below Aquifer Top

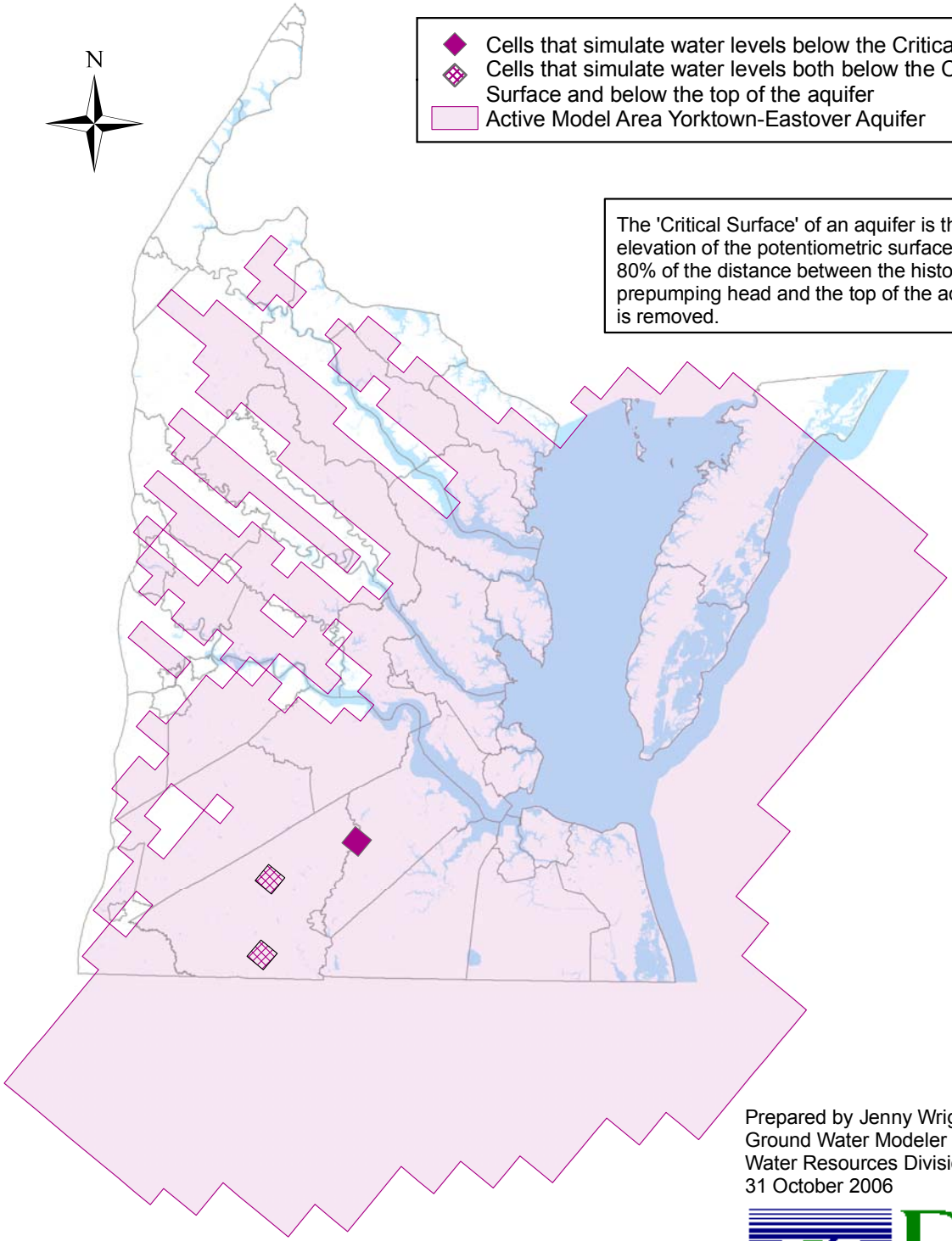


The 'Critical Surface' of an aquifer is the elevation of the potentiometric surface when 80% of the distance between the historic prepumping head and the top of the aquifer is removed.

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
31 October 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

2005 Total Permitted Use - Yorktown-Eastover Aquifer
Simulated Water Levels
Below Critical Surface and Below Aquifer Top



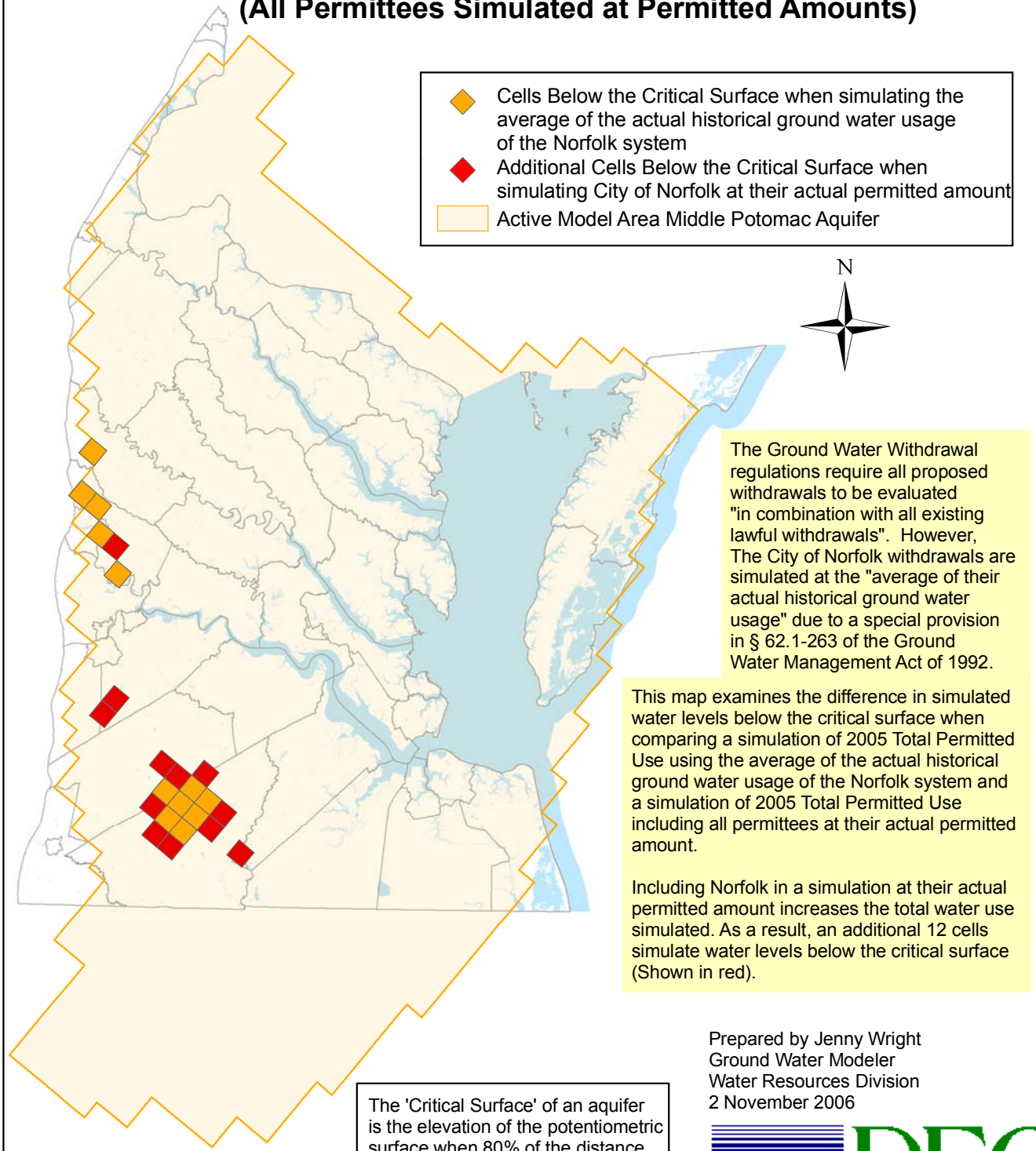
Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
31 October 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Attachment F

Changes to Simulated Water Levels Below Critical Surface (when simulating all permittees at their permitted amount)

Middle Potomac Aquifer
Simulated Water Levels - Below Critical Surface
2005 Total Permitted Use
(All Permittees Simulated at Permitted Amounts)



The Ground Water Withdrawal regulations require all proposed withdrawals to be evaluated "in combination with all existing lawful withdrawals". However, The City of Norfolk withdrawals are simulated at the "average of their actual historical ground water usage" due to a special provision in § 62.1-263 of the Ground Water Management Act of 1992.

This map examines the difference in simulated water levels below the critical surface when comparing a simulation of 2005 Total Permitted Use using the average of the actual historical ground water usage of the Norfolk system and a simulation of 2005 Total Permitted Use including all permittees at their actual permitted amount.

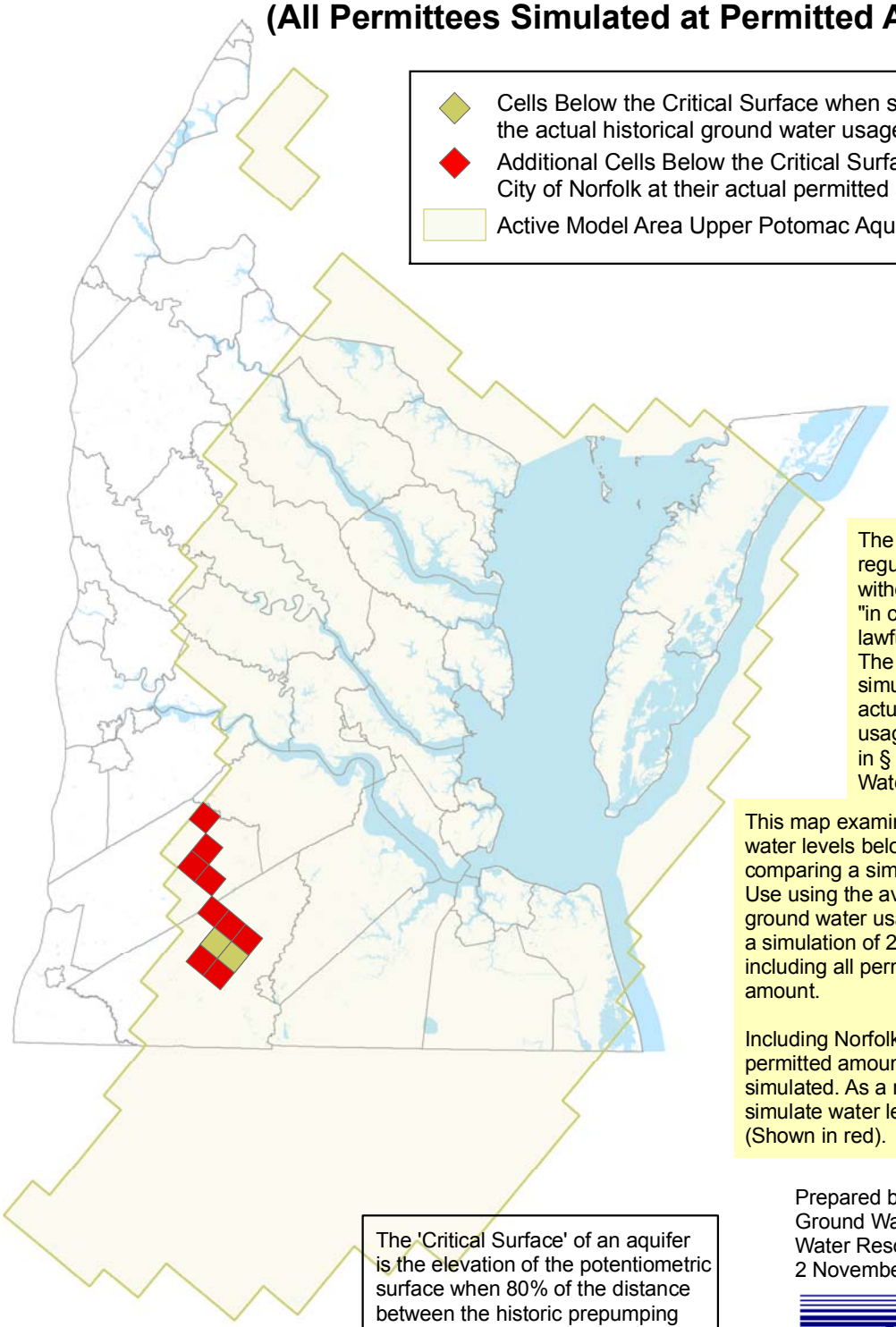
Including Norfolk in a simulation at their actual permitted amount increases the total water use simulated. As a result, an additional 12 cells simulate water levels below the critical surface (Shown in red).

The 'Critical Surface' of an aquifer is the elevation of the potentiometric surface when 80% of the distance between the historic prepumping head and the top of the aquifer is removed.

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
2 November 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Upper Potomac Aquifer
Simulated Water Levels - Below Critical Surface
2005 Total Permitted Use
(All Permittees Simulated at Permitted Amounts)



The Ground Water Withdrawal regulations require all proposed withdrawals to be evaluated "in combination with all existing lawful withdrawals". However, The City of Norfolk withdrawals are simulated at the "average of their actual historical ground water usage" due to a special provision in § 62.1-263 of the Ground Water Management Act of 1992.

This map examines the difference in simulated water levels below the critical surface when comparing a simulation of 2005 Total Permitted Use using the average of the actual historical ground water usage of the Norfolk system and a simulation of 2005 Total Permitted Use including all permittees at their actual permitted amount.

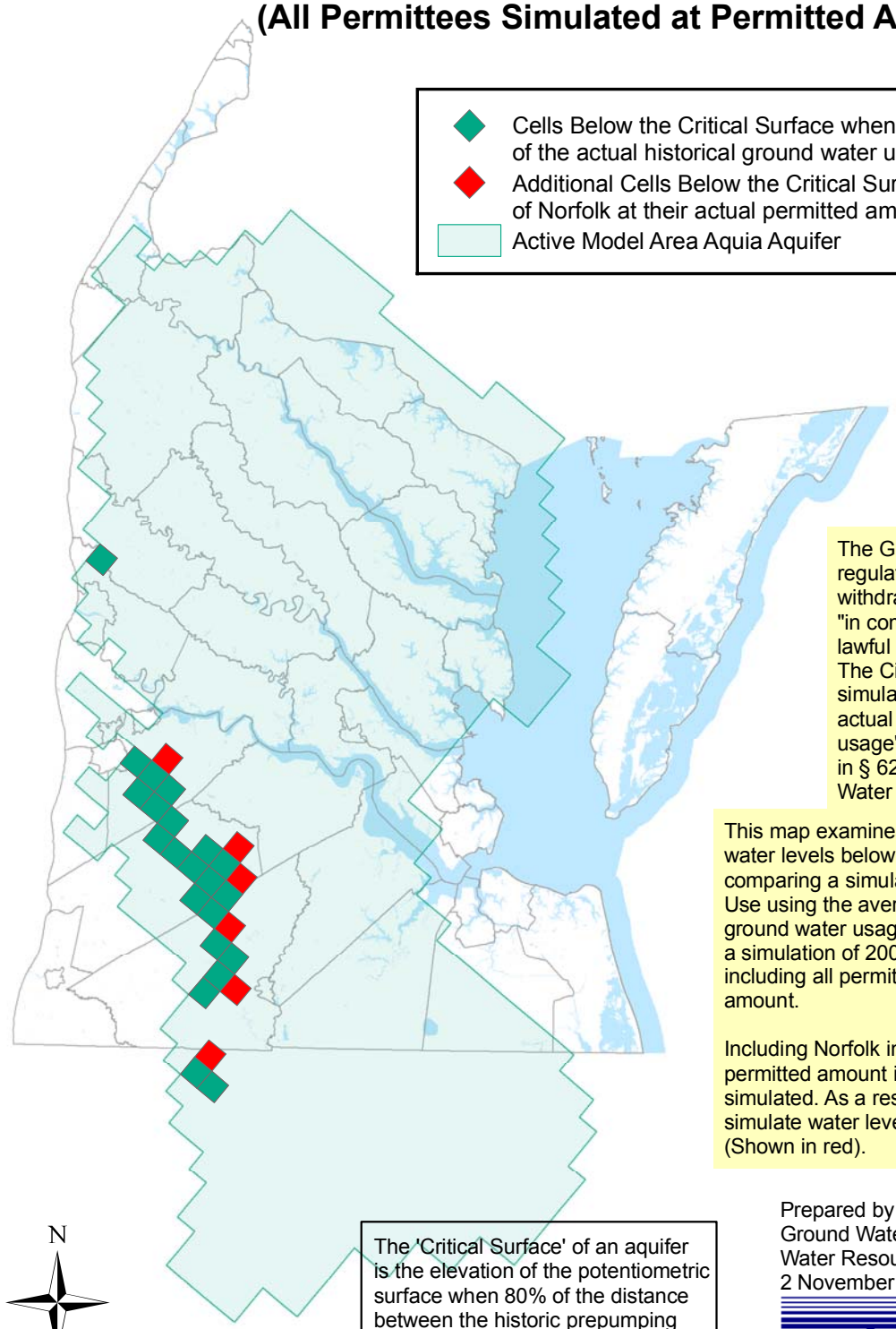
Including Norfolk in a simulation at their actual permitted amount increases the total water use simulated. As a result, an additional 9 cells simulate water levels below the critical surface (Shown in red).

The 'Critical Surface' of an aquifer is the elevation of the potentiometric surface when 80% of the distance between the historic prepumping head and the top of the aquifer is removed.

Prepared by Jenny Wright
Ground Water Modeler
Water Resources Division
2 November 2006

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Aquia Aquifer
Simulated Water Levels - Below Critical Surface
2005 Total Permitted Use
(All Permittees Simulated at Permitted Amounts)



The Ground Water Withdrawal regulations require all proposed withdrawals to be evaluated "in combination with all existing lawful withdrawals". However, The City of Norfolk withdrawals are simulated at the "average of their actual historical ground water usage" due to a special provision in § 62.1-263 of the Ground Water Management Act of 1992.

This map examines the difference in simulated water levels below the critical surface when comparing a simulation of 2005 Total Permitted Use using the average of the actual historical ground water usage of the Norfolk system and a simulation of 2005 Total Permitted Use including all permittees at their actual permitted amount.

Including Norfolk in a simulation at their actual permitted amount increases the total water use simulated. As a result, an additional 7 cells simulate water levels below the critical surface (Shown in red).

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The 'Critical Surface' of an aquifer is the elevation of the potentiometric surface when 80% of the distance between the historic prepumping head and the top of the aquifer is removed.

0 10 20 40 60 80 Miles

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